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THESIS

DIGITAL VIDEO (DV): A PRIMER FOR DEVELOPING
AN ENTERPRISE VIDEO STRATEGY

by

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September 2002

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DIGITAL VIDEO (DV): A PRIMER FOR DEVELOPING AN ENTERPRISE VIDEO STRATEGY

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I.   INTRODUCTION

A.   PURPOSE AND SCOPE

The purpose of this thesis is to provide an overview of digital video production and delivery. With today's vastly improved digital and video technologies, high-quality videos can be produced by just about any organization for inclusion into training and educational programs. The thesis provides a primer for understanding the process of planning, preparing, and publishing video content in support of distance training and education programs. The thesis can serve as a technical foundation for those individuals tasked with developing a strategy for providing digital video content in support of training and education programs within an organization. Resource managers may find this thesis helpful in providing a fundamental knowledge base to further assist in evaluating future decisions regarding investments in hardware and software products required to produce and deliver digital video.

The scope of this thesis oriented to those individuals responsible for developing digital video content into training and education programs. The thesis is not intended to fully examine nor completely debate the pedagogical arguments associated with the use of multimedia techniques in instruction. Research studies demonstrating the educational value of incorporating video and multimedia content in training and education programs are provided as the basis for developing a video strategy for any organization. However, this thesis makes no attempt to delineate the special requirements concerning the use of video multimedia by degree granting institutions. Additionally this thesis does not make specific recommendations regarding hardware and software combinations for delivering video content for distance training and education organizations.

B.   THESIS ORGANIZATION

Chapter One provides the purpose, scope, and organization of this thesis. Chapters Two through Nine follow and address the fundamentals of each associated topic. Each chapter describes essential terminology, definitions, and basic principles of the topic. Chapter materials serve as an introduction to the topic and are in no way

intended to be comprehensive. Further study of associated references, listed in the bibliography, may provide additional understanding and further clarification of a topic.

More specifically, Chapter Two discusses a brief history of distance training and education. Chapter Three outlines the audio and video production process. Chapter Four discusses the fundamentals for creating and developing blocks of instruction in support of training and education initiatives. Chapter Five introduces the various media input formats for capturing training and education presentations and lectures. Chapter Six surveys the most common digital media output formats and respective editing software packages. Chapter Seven outlines the requirements for and methods used in digital video compression. Chapter Eight discusses the methods available to distribute digital video content in support of distance training and education initiatives. Chapter Nine provides a glimpse of emerging technologies that will continue to fuel improvements to digital video capabilities.

II. DISTANCE TRAINING AND EDUCATION

A. DISTANCE TRAINING AND EDUCATION REACHES AN INFLECTION POINT

Interest in distance training and education is especially high in organizations where the organization's population tends to be widely distributed. The term distance training could be used to describe a wide range of nonresident training and educational programs and initiatives. The characteristics of distance training and education programs typically include: separation of instructor and student in space or time or both, the control and pace of learning controlled by the distant student rather than the instructor, and asynchronous communication between student and instructor (Sherry, 1996).

B. DISTANCE TRAINING AND EDUCATION CHRONOLOGY

The general form of distance training and education has been in existence in one shape or form since the 1800s. Distance training and education has essentially been in existence since the advent of the written word. The following discussion provides an overview of the chronological history of distance training and education.

1. The 1800s

Distance training and education was originally known as "correspondence study." With correspondence study, a school or other qualified institution provides text-based course materials to its enrollees. Much like today, students received all training materials (syllabus, readings, exams) through the postal mail system. Depending on the design of the course, students would complete required tasks and submit the necessary assignments and papers back through the mail, thus corresponding with the course instructor or facilitator. In 1873 Anna Ticknor, the "mother of American correspondence study," established the Society to Encourage Studies at Home in Boston, Massachusetts (Nasseh, 1997). The purpose of her organization was to provide educational opportunities for women across all socio-economic and class boundaries. Although the organization began with humble beginnings, over its 24-year history, 10,000-plus members participated in various course offerings. By the end of the 1800s the mine, railroad, and iron industries began using correspondence study to provide training and education to its workers. In 1891 the Colliery Engineer School of Mines offered the first mine safety home study

course. Within a year similar courses were developed and offered for railroad workers and iron hands. Shortly thereafter the Colliery Engineer School evolved into the International Correspondence Schools (ICS) and is known today as Education Direct. Today Education Direct claims to have enrolled over 12 million students throughout its 100-plus year history (Thompson Education Direct, 2002). Approximately one million students remain enrolled in traditional correspondence courses every year (Porter, 2001).

2.   **Early 1900s**

In the early 1900s a proliferation of educational institutions (colleges and universities) and other qualified organizations offering correspondence study occurred. In 1920 the United States Marine Corps began its own distance training and education initiative, becoming the first military service to establish such a program. Through the Marine Corps Institute, the Marine Corps began enrolling Marines in both vocational and baccalaureate courses (Marine Corps Institute, 2002). Although Marchese Marconi had invented the wireless telegraph (radio) approximately twenty five years earlier, it was not until the 1920s that educational institutions attempted to leverage radio technology as a delivery medium for distance training and education.

By 1923 about 10 percent of all broadcast radio stations were owned by colleges or universities providing some type of educational programming (Public Broadcasting Corporation, 2002). That same year Vladimir Zworykin patented the television camera tube (iconoscope), thus spawning the development of broadcast television and giving birth to another technological innovation used to deliver distance training and education. Although the popularity of instructional radio begins to climb, only one college-level credit course was offered via radio broadcast.

3.   **1960s and 1970s**

During the 1960s and 1970s correspondence study continued to flourish as television and radio broadcasts licensing began to take hold amongst universities and colleges. In 1969 President Lyndon Johnson signed the Public Broadcasting Act, establishing the creation of the Corporation for Public Broadcasting (CPB) to promote noncommercial use of both television and radio. The CPB charter was to develop high-quality programs, to establish a network for their distribution, and to strengthen local

support for public television and radio stations. Shortly thereafter the Public Broadcasting System (PBS) and National Public Radio (NPR) were established (Public Broadcasting Corporation, 2002).

In 1970 Dr. Bernard Luskin (Figure 1) developed the first "tele-course," touted as a complete course of study in a given subject, as opposed to other distance training and education technologies such as movies, filmstrips, slide shows, audiotapes, or vinyl records. With the tele-course, students and instructors were physically separated, but maintained communication via television broadcast between the student and instructor locales. Tele-courses enabled real-time instructional functions such as answering student questions (in real-time), reporting student progress, and enabling student testing.

Figure 1.   Dr. Bernard Luskin (Media-Visions, 2002)

Interestingly, distribution of Dr. Luskin's tele-courses was assigned to a new, third-party organization, named Coastline Community College. Bear in mind, Coastline Community College was simply an organization established to distribute the tele-courses – it had no physical campus. Coastline Community College arranged for Dr. Luskin's tele-courses to be made available to the public via broadcast by a public television station thus becoming the first "virtual" college (Public Broadcasting Corporation, 2002). A year later, Intel invented the first microprocessor, thus foreshadowing another innovation in the delivery medium for distance training and education.

4. The 1980s

In the 1980s, various technological improvements fueled the growth in broadcast technologies and subsequently, satellite television networks were specifically developed to deliver distance training and education. In 1981 PBS established the Adult Learning Service (ALS), a programming service devoted to National delivery of training and educational content. The ALS consisted of approximately 200 public television stations and 2,000 universities and colleges delivering tele-courses for college credit, with an enrollment base of a half-million students. By the mid-1980s, the first distance training and education cable network was established. In 1985 the National Technological University (NTU) opened as a fully accredited university offering graduate education courses in engineering. Courses were up-linked to NTU via satellite from a number of originating universities and subsequently re-broadcasted via satellite. In 1987 Mind Extension University (ME/U): The Education Network, served as the first "global electronic campus," providing access to courses and degree programs from dozens of leading colleges and universities, including California State University at Dominguez Hills, George Washington University, University of Colorado at Colorado Springs, and University of Delaware (Digital Century, 2002).

5. The 1990s to the Present

By the beginning of the 1990s, the first online degree programs were made available by the University of Phoenix and eConnect-Ed. In 1991, Tim Berners-Lee developed the World Wide Web (WWW); shortly thereafter, there was an explosion in computer network connectivity throughout the world. By 1997 the California Virtual University, a consortium of approximately one hundred California universities and colleges, made available over 1500 online courses. The growth of online learning continued; and by the end of the decade, Web-based course management systems such as Blackboard and eCollege, were borne out of the recognized cost-benefit associated with outsourcing online training and education infrastructures. Today colleges and universities, K-12 school districts, and corporate training organizations continue to partner with private firms that assist in the design, building, and support of online learning communities.

C. SUSTAINING GROWTH FOR ONLINE DISTANCE TRAINING AND EDUCATION

Given the rate at which Internet technologies advance coupled with the abundance of personal computers, the Internet, Compact Disc-Read Only Memory (CD-ROM), and Digital Versatile Disc (DVD) based delivery of distance training and education may be poised to become the largest medium for distance learning (Public Broadcasting System, 2002). As post secondary institutions look to increase their delivery of distance training and education, the chosen favorite medium for delivery will be the Internet, with interactive and pre-recorded video content (National Center for Education Statistics, 1999). By providing training and instruction via the Internet, Local Area Network (LAN), or on a local machine via a CD-ROM or DVD, anyone can participate in interactive training and educational content no matter where they are located. High-speed computer network architectures and low-cost, high-storage optical media have the potential to greatly expand and enrich the design of traditional correspondence course-styled, text-based instruction.

However, it remains to be seen whether distance training and education over the networks or via CD-ROM will meet both student and instructor expectations. Like many dot-com ventures launched in the mid 1990s, many online distance training and education initiatives have experienced difficulties finding the path to profitability and legitimacy. In November 2001 New York University (NYU) Online, a for-profit distance learning portal, closed down after just three years of operations and incurring costs of over $25 million dollars (Academe, 2002). The university's inability to deliver on the promise of providing a compelling educational experience through virtual classrooms and cyber lessons is worthy of further examination.

Recently online distance training and education programs associated with University of Maryland University College and Temple University closed down after years of excessive start-up costs, low revenues, and shrinking reserves for capital investment expenditures. Two main reasons are often attributed to the failure of a distance training and education venture: money and content. The first has to do with pure economics – a given distance training and education program fails due to a lack of overall funding or simply takes too long to attract sufficient student enrollment levels to achieve

any major economies of scale. The second reason for failure most often cited with online distance training and education failures is the educational "experience" offered simply fails to provide a compelling student learning experience. Andrew Feenberg (Figure 2), a San Diego State University professor and cofounder of the first-ever online education program, discusses the reasons for the recent failures of online distance training and education programs:

> To sell something, you need customers who want it, and you need to be able to supply it to them…no one really knows how to do online education well enough to make students happy with the product (Academe, 2002).

Figure 2.   Dr. Andrew Feenberg (National Crosstalk, 1999)

D.   ONLINE DISTANCE TRAINING AND EDUCATION STUDENT COMPLETION AND RETENTION RATES

Unfortunately no national statistics exist regarding the numbers of students completing online distance training and education courses, but considerable evidence suggests actual online distance training and education course completion and program retention rates are generally lower than their resident or face-to-face counterparts. Completion rates vary among higher education institutions; while some find course completion rates better than 80 percent, others report fewer than 50 percent of online training and education students finish their courses (Carr, 2000). Several administrators admit course completion rates are typically 10 to 20 percent lower than the traditional, resident, face-to-face classes (Carr, 2000). Corporate training and education organizations find learners leave online courses far more often than they drop-out of traditional classroom settings. Jeanne Meister, president of Corporate University

Xchange, reports online learners demonstrate course completion rates of 30 percent, or a drop-out rate of 70 percent. According to the firm's most recent study, online course drop-out rates are far higher that the traditional classroom drop-out rate of 15 percent (Alexander, 2002).

Reasons for the differences in these rates are usually attributed to either student demographics or the nature of distance learning itself. Typically, online distance training and education students are older; have jobs and family, and therefore tend to be usually busier than typical resident-type students and remain prime candidates for course incompletes, drops, and withdraws. Others in academe argue that the format of current online distance training and education courses fail to inspire and motivate students to learn (McGinn, 2000).

Dismal as the online drop-out rate is at some institutions, it still represents an improvement from the previous years' when as many as 85 percent of online learners failed to complete courses (Alexander, 2002). Training and education institutions must concern themselves with determining why so many students leave online courses without completing them. Drop-out rates are not the only measure of success for online course offerings. But some learning professionals lament the drop-out rate is due to poor instructional designs which result in online courses which are too long and boring (Alexander, 2002). To improve the quality of online courses, multimedia must employ good design, pleasing aesthetics, and a certain degree of excitement. The same learners who are online learners during the day, are Web and television consumers by night. Sensitized by the high volumes of consumer media, online learners are easily bored or put off by poorly produced online educational content (Schmitz, 2002).

E. **IMPROVING QUALITY OF DISTANCE TRAINING AND EDUCATION THROUGH THE USE OF AUDIO/VIDEO TECHNOLOGY**

Independent research has demonstrated that visual imagery associated with instructional television or video can motivate and captivate students, thus stimulating a greater interest in the learning process and overall educational content. However, any over reliance on video technology itself for the purposes of entertainment is a mistake.

Reliance on visual presentation alone can distort the learning process by focusing students' attentions on the entertainment value or a given

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production technique vice the encouragement of insightful reflection as to the underlying meaning of the content of instruction itself (Ravitch, 1987).

1.   **Pike Study (1994)**

Pike's study examined how students' memories become permanent and determined the permanence of a learning experience is a function of how strongly information is registered during the initial training and education. Learning through listening and watching was deemed very powerful. Pike's study supported the following conclusions (Pike, 1994):

- Adult students learn 75 percent of what they know through vision.

- Adult students learn 13 percent of what they know through hearing.

- Adult students speak 110 to 160 words per minute (WPM) but think at a rate of 400 to 500 WPM.

- Training and educational content retention is improved by 14 to 38 percent through the use of audio and visual technologies.

- Time to present training and educational content are reduced up to 40 percent when using audio and visual technologies.

2.   **Millbank Study (1994)**

The Millbank study examined the overall effectiveness of a combination and mix of audio and video during corporate-style training. When such audio and video technologies where introduced into the learning materials, the subsequent retention rates of the trainees rose from 20 percent for those using ordinary "analog" classroom methods to approximately 75 percent for those using audio and visual technologies (Millbank, 1994). Overall, the result Millbank's study reinforces the intuitive notion that implementing video technology into appropriate online distance training and education courses can prove to be an effective mode of delivery for course content while improving its overall quality.

3.   **Guzley and Boar Study (2001)**

A recent study conducted by Guzley and Bor regarding the test of motivation, interaction satisfaction, delivery, learning, and perceived effectiveness in video distance learning supported the following conclusions (Guzley and Bor, 2001):

- Students have a high degree of comfort with the use of video technology in support of online distance training and education course materials.

- Students have a more favorable view of instructional video materials than purely text-based instructional materials.

- Students indicated a favorable view of a given instructor's presentation via video as opposed to purely text-based instructional materials.

- The students' high degree of comfort associated with the use of video technology had a strong and significant correlation with overall student satisfaction levels.

- The quality of instructional video demonstrated only a moderate but nevertheless significant correlation with student satisfaction.

These results of these studies should not be misconstrued to indicate that video multimedia alone is the single factor of importance. Successful online distance training and education designs incorporate well written and conceived instructional content. High levels of interactivity between teacher and student are often achieved through various technological means such as network-based textual materials, online chats, forum discussions, and supporting e-mail correspondence. It is the combined use of various technologies, to include audio and video multimedia, which can in enhance student learning, interaction, comprehension, and retention of course materials.

F.   A   CALL   FOR   THE   INCREASED   USE   OF   AUDIO/VIDEO TECHNOLOGY   IN   EXISTING   DISTANCE   TRAINING   AND EDUCATION PROGRAMS.

Good classroom pedagogy is good pedagogy for distance learning (Schlosser and Anderson, 1994).

Although the benefits of incorporating interactive multimedia and various modalities of instruction into distance training and education programs are evident, video has yet to be incorporated into course content extensively. For example, the Marine Corps Institute (MCI) offers over 103 Military Occupational Specialty (MOS) Courses and 7 Professional Military Education (PME) programs consisting of 40 courses. However, only 7 courses are Web-based courses, and only 12 have made their way to CD-ROM (Marine Corps Institute, 2002). Although MCI courses are available through network technologies (via a download), the training and educational content remains

primarily text-based, following the 1800s "correspondence study" format. On the whole, use of video and audio technology has yet to reach a high adoption rate within current online MCI course offerings.

In the past, the lack of audio and video multimedia within distance training and education programs was largely attributed to significant difficulties in video production, synchronization and infrastructure (Schmitz, 2002):

- Production - Due to the inherent limitations of existing consumer video production equipment, it was difficult to simply record quality video and audio. A major impediment to most organizations was the requirement for skilled professionals to set up and operate, cameras, lighting, and sound equipment.

- Synchronization - A lack of consumer oriented post production tools made it difficult to synchronize lectures, classes, and speeches, with supporting presentation materials such as slides, whiteboards, and student feedback and questions.

- Infrastructure - Immature network, compression, and storage media technologies created severe limitations on the ability to deliver high-quality video content via the Internet or CD-ROM.

However, recent technological developments in digital video cameras, video hardware/software technologies, and related applications are making the use of audio and video more feasible. Increased sophistication and usage of electronic slide presentation software packages supporting video media has made synchronization of lecture and slides easier. Drastic improvements in audio and video editing technologies, software applications, and modes for their distribution, coupled with significant price reductions for such offerings, should prompt organizations responsible for training and education to embrace and encourage the significant use of audio and video content (where applicable) in future online distance training and education programs.

III. DIGITAL AUDIO/VIDEO PRODUCTION PROCESS

A. INTRODUCTION TO PRODUCING AUDIO/VIDEO CONTENT FOR NETWORK/CD-ROM DELIVERY

The need for ensuring reasonable quality of delivered audio and video content has not changed since the 1960s. Quality of service (QoS) pertains to giving viewers the clearest, largest possible pictures, without significant noticeable interruption or downtime. Today those same (QoS) issues exist for digital audio and video content delivered via either computer networks or Compact Disc – Read Only Memory (CD-ROM) technologies. While digital audio and video has the ability to record and produce high quality sounds and pictures, ultimately it is the mode of delivery of such digital content that presents the most significant challenge. To deliver digital media content, the resulting large-sized data files must be compressed, and in doing so, reduce the quality of the original digital media. Initial implementations of audio and video multimedia in online distance training and education programs resulted in small, grainy, flickering, poor-quality video presentations of course materials. However, with today's vastly improved digital and video technologies, more robust, higher-quality videos can be produced, by just about any organization, for inclusion into training and educational programs.

B. DIGITAL AUDIO/VIDEO PRODUCTION PROCESS

To ensure the successful inclusion of digital audio/video multimedia components into any distance training and education program, the following process is provided. In general, most audio and video projects follow this sequence:

- Plan – the developing and preparing of a various strategies for capturing instruction.
- Capture – the method and process of recording audio and video with various equipment.
- Edit – the process in which raw video is refined, enhanced, and saved as an uncompressed video file.
- Compress – the process in which the size of an uncompressed file is reduced via various compression algorithms.

- Deliver – the method and process in which final, compressed files are delivered to viewers.

IV.   PLAN

A.   INTRODUCTION

Within the confines of distance training and education, there are many different types of video productions. It is important to understand that simply inserting video into training and education does not eliminate the need for solid content behind it or the critical value that instructional design plays in shaping how video media is utilized (Rosenberg, 2001). There are numerous design decisions made throughout the course of developing a video project in support of distance training and education. The various choices regarding what type of media, what kind of shots, and how video content will be distributed are important elements contributing to the success of the project. For example, using "free form" video such as lectures, demonstrations, interviews, or documentary style formats can all be appropriate strategies for conveying desired learning objectives and outcomes.

Even "dramatic form" videos can be used to tell stories that convey learning objectives or simulate behaviors that would otherwise be impractical to demonstrate in a traditional classroom setting. However, these dramatic-styled videos require significant planning and production techniques to successfully complete. Conversely, free-form style videos are generally easier and less expensive to create and are most compatible with existing training and education programs. All of these instructional design choices possess inherent advantages and disadvantages that must be understood and considered prior to the shooting of a training and education video.

B.   ELEMENTS OF PLANNING

As with any endeavor, the better conceived and more thoroughly it is planned, the easier it is to complete; resulting in a better end product. Alfred Hitchcock once stated that just about anyone could successfully direct his films. Prior to filming, Hitchcock meticulously planned every detail in his film so thoroughly in advance that by the time it came to actually shoot his films, anyone could have done it (Hoffman, 1999). Similar to any other type of instructional product, the first step in developing digital audio and video

content is to conduct a front-end analysis that will serve as the framework for subsequent video project production decisions.

1.   General Course Instructional Planning

As with any good presentation or course, it begins with an end state in mind. In order to do so, course content developers should carefully answer the following questions (Palloff and Pratt, 1999):

- What is the objective of the instruction?
- Who is the intended audience?
- How do we perceive students interacting with instructional materials?
- What skills and abilities are targeted to students?
- What are student's attitude towards instruction and educational materials?

The development of instructional objectives for a video project in support of distance training and education does not differ significantly from the development of objectives for the traditional resident course. By first conducting a "top-level" analysis, subsequent decisions regarding how video content will be shot, delivered, and what types of hardware and software will be required to produce the project can be made to support underlying high-level requirements.

2.   Video Content Planning: How to shoot instruction

One of the most important outcomes of the top-level analysis is determining how we perceive students interacting with the instructional materials. From these discussions, a decision regarding what type of video to shoot can be made. Whether filming a speech, interview, or scripted dramatization, all of these formats have their own special set of concerns and requirements. The following discussion outlines some of the various implications associated with each type of shoot and useful techniques for to best capture training and education content.

a.   Filming Tips: Speeches and Presentations

The biggest concern when filming instruction is sound quality (Pouge, 2002). When filming a live presentation or lecture, the typical microphone in the average digital camcorder is ineffective at distances greater than approximately 10 feet (Whong, 2001). Most camcorders are equipped with an "area" microphone that picks up every

nearby sound. Background noises emanating in the vicinity of the camcorder can drown out your speaker. To remedy this situation, additional equipment is required. Most camcorders have an input for an external microphone. External microphones are recommended for any situation in which there is direct audio recording, such as an interview, live speech, or presentation (Steward, 2002).

Another problem specifically associated with capturing classroom lectures or presentations for use in training and education video content is how to adequately capture instructor and student classroom interaction. Many times when a question is posed to the instructor, there is not sufficient warning or time to properly train the camera on the student asking the question. Capturing communication between student and instructor can further support course content and promote effective learning in video multimedia (Sipusic, Pannoni, Smith, Dutra, Gibbons, and Sutherland, 1999). There a few techniques that may be employed to overcome the problems associated with question and answer periods. One simple method is to have the instructor repeat the question to the camera prior to providing the answer. Another technique is to have students and instructors pause briefly before posing or answering questions, thus giving the camera operator time to train the camera on subjects. Depending on the size of the classroom or lecture hall, it may be possible to disconnect the input for the external microphone momentarily to capture a question from a student. With the external microphone disconnected, the internal microphone of the camcorder records the question. After the question is asked, the camera operator can reconnect the external microphone prior to the instructor responding to the question.

A final problem associated with filming live classroom instruction is the lack of variety in camera shots and angles. Typically lectures are shot with a single camcorder positioned in a stationary setting. The camcorder operator pans left and right to follow the presenter adjusting the picture zoom as required. Lack of movement or action by the presenter can often result in video that lacks inspiration and fails to motivate students to learn. In simple terms, it is just plain boring. In these cases, shots of audience participation and reactions to instruction can be intermingled with the video clips of the presenter. Cutaway shots of the audience are one way to introduce variety into the video project.

b.   *Filming Tips: Interviews*

When capturing interviews as part of video content for distance training and education courses there are two essential elements: the camera set-up and the point of view. The camera set-up for the interview refers to how the participants are to be positioned (Whong, 2001).   There are two basic themes to choose from: will the interviewer and subject be positioned in such a way so the camera can see both their faces at the same time, or will they be facing each other similar to on-the-street interviews (Cornell University, 1998)? In either case, "establishing" shots are required to show the participants positioning, followed by medium or close-up shots of the participants as the interview progresses (Figure 3).

Choosing a point of view is equally important during the filming of interviews. Planning considerations should determine whether students will be simply "watching" the interview or interacting with it (Pouge, 2002).   If students are merely watching the interview, the on-camera subject should not look directly into the camera.

Figure 3.   Interview Point of View (Whong, 2001)

Conversely, if the students are interacting with the on-camera subject, the subject should always maintain eye contact with the camera, just as they would with a person. Mixing the two point of view techniques often paints the on-camera subject in a negative manner; giving them the appearance of being overly self-conscious or unsure of themselves (Cornell University, 1998).

A final planning consideration for interviews is the role and visibility of the interviewer. Will the interviewer be part of the interview (Pouge, 2002)? If so, the technique of capturing supplementary footage before or after the interview is necessary.

Taking supplementary footage of the interviewer nodding in approval, smiling, reacting, can be spliced into the interview providing variety to the finished video product. Conversely it is completely acceptable not to include the interviewer in the video. In this case, you simply use the interviewer's voice; this is commonly referred to as a voice-over (Pouge, 2002).

As one could surmise, capturing interviews are more difficult to set-up and will require more skillful editing than simply recording a presentation or lecture. However, interviews can expose students to subject matter and points-of-view that could not otherwise be delivered by a single presenter or lecturer. Interviews add variety and inject personality into training and education content.

c.   *Filming Tips: Demonstrations*

Demonstrations are particularly useful for training and education because they can display how to perform certain tasks. However, there are some specific techniques that need to be applied in to maximize the value of a demonstration on film. First, the presentation should be divided into a few manageable segments. For each segment, the entrances, exits, and movements that will be necessary in order to perform the demonstration should be planned in advanced. The best camera angle for getting the picture of what is actually being demonstrated needs to be determined. Likewise a decision regarding whether the on-screen demonstrator will be providing the narration or if it will be provided afterwards as a voice-over is a necessary consideration. With either technique, providing continuous narration throughout the demonstration is essential to show what is happening during the demonstration without the need for continuous close-up shots.

"Establishing shots" are important to help orient the viewer as necessary to the location of objects that will be used during the demonstration (Cornell University, 1998). Precise camera shots on the most important moments during each particular segment of the demonstration will ensure essential elements are captured. Wide shots, followed by close-ups help to keep the viewer visually engaged in the subject at hand, while accompanying narration provides explanations to the pictures that student will be viewing.

d.   *Filming Tips: Scripted Scenes/Dramatization*

Stories give learners another opportunity to take in and relate to training and education content. Dramatizations enhance the educational experience because an episodic story mimics the structure and emotional intensity of direct experience (Underhill, 2000). Of all the types of settings described so far, scripted scenes or dramatizations are by far more complex and resource consuming than the other types of shots. In addition to all the techniques and technical considerations already mentioned, the crafting of the "story" becomes equally important. Most scripted scenes begin with what is called a "treatment." A treatment is not a line-by-line script per se but a prose-styled synopsis of the scene's story line (Pouge, 2002). Once approved by the various stakeholders associated with a block of instruction, a line-by-line manuscript can be developed. A well-told story has a meaning that is clear to the learner, with clearly defined characters, a strong plot, and plenty of action (Underhill, 2000). Once a script for your video is written, significant planning must take place to produce the various scenes. Making decisions about who will play the roles and where will the scene be shot require extensive planning skills. Locations, props, sets, and participants are just the beginning. Most training and educational institutions do not possess the requisite skills to take on such projects. Scripted scenes and dramatizations are best left to professional video production companies or those individuals with specific experience in video production.

3.   Content Delivery Planning: Deciding on Delivery Methods

Once it has been decided on what content will be provided to the student, the next planning factor to consider is what is the best way to deliver produced video content. There are basically two choices for delivery: via a network or the learner's stand-alone machine. To help facilitate that decision, there are a few important factors to examine in terms of available access to the network, available bandwidth, portability, and content control. These topics are fully discussed in subsequent chapters, but it is important to recognize these factors prior to beginning the video production process so as to make the best choices during the remaining steps of the video production process. Choices made during the planning phase will have a dramatic effect on picture quality, data delivery rates, and compression schemes applied later.

a.   *Network access speeds*

If a given distance learning architecture includes providing video content over a network, it is important to recognize certain attributes of the learning audience for which the files are intended. In planning the distribution of online video content in support of training and education, consideration must be given to learner access capabilities. Digital Video (DV) files are quite large, and subsequently require large amounts of bandwidth to transfer them to users. Over the past few years the method in which home users connect to the Internet has been changing from narrow-band, low-speed connections to broad-band, high-speed connections. In 1999, Nielson Net Ratings reported (Figure 4) most home users accessed the Internet via a 28.8/33.3 kilobit per second (kbps) connection (Client Help Desk, 2001).
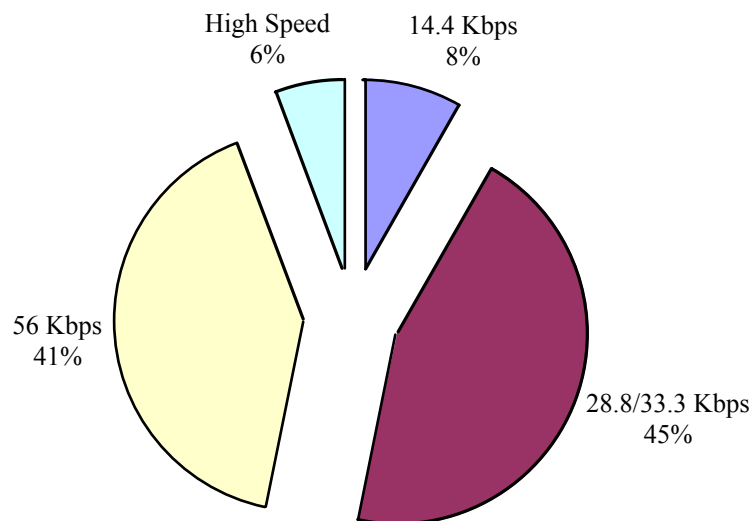
Figure 4.   Home Connection Speeds, 1999 (Client Help Desk, 2001)

In the fall of 1999, over 85 percent of home based Internet users accessed the Internet at speeds considered too slow for the delivery of high quality video files. However by February 2001, the numbers of home users connecting to the Internet at the low-speed had dropped (Figure 5) while the totals of user connecting via higher-speed connections increased significantly (Client Help Desk, 2001).
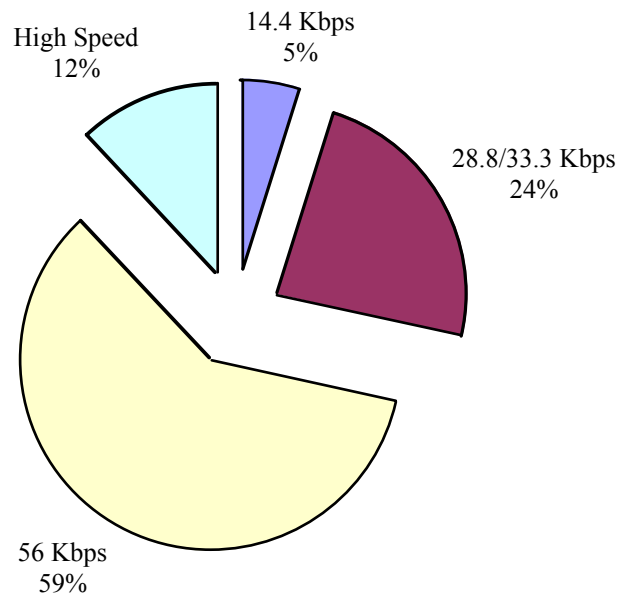
Figure 5.   Home Connection Speeds, 2001 (Client Help Desk, 2001)

In April 2002, Nielsen Net Ratings reported that nearly 25 percent of home Internet users were connecting via a high-speed connection. Today large broadband networks are achieving significant audience gains as their growth continues to increase. Access to broadband networks is becoming more available to home learners, thus providing the necessary infrastructure required to deliver high quality video files over the Internet. By the summer of 2002, the biggest broadband cities continued to get bigger. Recently, 65 percent of the top broadband metropolitan areas posted at least a 48 percent gain in subscribers from last year (Nielsen/Net Ratings, 2002). Such robust growth in the population of high speed connections signals the infrastructure problems associated with distribution of video content via the Internet will most likely be solved in the coming years (Schmitz, 2002).

b.   *Optical Discs (CD-ROM and DVDs)*

Although broadband networks are becoming more and more available to the average user, Compact Disc – Read Only Memory (CD-ROM) media remains a strong candidate for the delivering instructional training and education videos. The CD-

ROM is ideal for the delivery of video content due to their high data delivery rates. The CD-ROM has data capacities of up to 700 Megabytes (MB) can hold hours of high quality video and alleviate the requirement for a connection to the Internet or network for viewing. Digital Versatile Discs (DVDs) tout capacities up to 4.7 Gigabytes (GB) and are capable of storing hours of high quality full digital video. With CD-ROMs and DVDs, viewers have the ability to view materials, whenever, wherever, without the need of a network connection. Additionally, optical discs remain very portable, making it very easy for mobile users to literally take instructional media with them wherever they travel. However, depending on the volatility of the training and education content distributed via CD or DVD, strategies for updating course materials should be explored. Small updates to course content could be provided via the Web in the form of a download, whereas significant changes to course content may render the content on a CD or DVD obsolete. Consideration for updates should be considered when developing strategies for the delivery of course video content.

4. Content Delivery Planning: Media Formats

Another planning consideration is deciding which media format will be used in used during video production. The implication of picking a video format will dictate certain hardware and software requirements that come into factor during the video production process. For video files that will be downloaded or supplied via disc, the most popular media formats today are QuickTime (.mov), Moving Picture Experts Group (.mpg), and Audio-Video Interleaved (.avi) (Lengel, 2002). All three file formats are viable video formats and are in wide use today. The following discussion provides a brief overview each media format.

QuickTime is produced by Apple Computer and can be played and used for both playback and authoring on both Macintosh and Windows operating systems. The QuickTime Player and its browser plug-in supports a multitude of file formats such as .avi and .mpg files, and it supports a variety of other codecs for audio and video (Apple Computer, 2002). QuickTime reaches about 29 percent of the Internet population at home, totaling approximately 13 million users (Olsen, 2002).

Moving Picture Experts Group (MPEG) is an International Standards Organization (ISO) that devises the MPEG system of compressing video and animation data files. The MPEG standard is not a proprietary format and can be displayed by both QuickTime and Windows and Real Media players.

Audio-Video Interleaved (.avi) is produced by Microsoft and Intel and serves as a format to store and display video files with sound (Lengel, 2002). Users may play Audio-Video Interleaved files using the Window Media or QuickTime Players and plug-ins. Microsoft's Windows Media Player accounts for approximately 53 percent of the viewing public for home users (Olsen, 2002). Both QuickTime and Audio-Video Interleaved file formats define the way the data is stored with a file. These formats can use a variety of compression schemes to compress data.

For video files that will be streamed or supplied via a dedicated server, the most popular media formats used are Real Video (.ram), Quicktime(.mov), and Windows Media (.asf) (Lengel, 2002). All streaming formats are similar in performance and capabilities. Real Video is developed by Real Networks to work with the Real Video Player and Real Video server. Real Networks leads the way in media players with 60 percent of home users watching video or audio content with its player. Note the percentages between QuickTime, Windows Media, and Real players total more than 100 percent because many users have downloaded and use more than one player for viewing needs (Olsen, 2002). The file format that an organization chooses depends on its compatibility with existing video-editing capabilities, the audience's plug-ins, and the organization's various servers.

V.   CAPTURE

A.   TYPES OF VIDEOTAPE MEDIA

Traditional video, such as the video seen on television, is analog. Analog refers to an electrical signal that is continuously variable (Tomasi, 2001). When video taping, the camera scans the subject and converts the available light as it enters the camera. The light is converted into electrical impulses, which correspond to the available light or "brightness" of light bouncing off the subject and surrounding background along with changes sound frequency and magnitudes. The scan proceeds as a collection of narrow lines across the subject – 480 lines from top to bottom at a rate of 30 scans per second. From these scans, a continuous signal is produced and is sent via a transmission medium (wire, cables, or radio wave) to a television receiver. The television receiver then displays the lines on the television or monitor screen in the same continuous 480 lines, 30 times each second. Traditional videotape then stores the continuous signal or waveform of electrical impulses so it can be saved and played back at a later time on a videocassette receiver (VCR).

B.   ANALOG VIDEO TAPE FORMATS

Although the video industry is in a transitional period between digital and analog video formats, there are numerous analog videotape formats still widely used today. Some training and education organizations have yet to purchase digital video cameras and may find any number of different video camcorders and tape formats. Likewise some organizations may already have an existing catalog of training and education content. Such existing video content need not be discarded. It is possible to transfer video content from tapes into a digital format. Analog to DV bridges are discussed in Chapter Six.

1.   VHS (Video Home System)

This format is found in nearly all home VCRs today. Originally introduced by JVC in 1976, the VHS format remains extremely vital in terms of distribution of taped programs. The "technical" problem with the VHS format as compared to the DV format is the quality of the image on the tape is not really very good (Stern & Lettieri, 2001).

These cameras accept full size VHS cassettes that, after filming, can be inserted directly into a VCR for playback. However, the size, weight, and bulk associated with these cameras, coupled with lack of editing options resulted in a low adoption rate by consumers and professionals alike. Only a handful of full-size VHS camcorders are still available on the market today.

2.   S-VHS (Super VHS)

The S-VHS was an improvement to the VHS format. By processing color and brightness signals via separate channels, image color and sharpness are improved. The S-VHS is sometimes used for broadcast video at smaller-market stations and widely a common format for nonbroadcast video projects. However, S-VHS capable cameras are usually more expensive than their VHS counterparts and require S-VHS equipped VCRs and televisions to take advantage of the improved signal quality.

3.   VHS-C (Compact)

The VHS-C is Panasonic's solution to the bulkiness and weight of the VHS camcorders. The VHS-C cassette is considerably smaller than the VHS cassette, therefore giving way to lighter and smaller cameras. However, to play a VHS-C cassette in a regular VCR requires an adaptor cassette to be purchased separately.

4.   Betacam/BetacamSP

Originally introduced by Sony in 1982, the Betacam failed to achieve the same level of consumer adoption as VHS. Although the Betacam and its player (the Betamax) boasted greater picture and sound quality, its price differences were not matched with consumer's perceptions to ensure its wide range adoption in the marketplace. It is currently marketed for broadcast use, although there have been some less-expensive models designed for both professional and consumer use.

5.   MII

The MII was Panasonic's answer to Sony's Beta products. Like Betacam, MII uses a metal tape but was significantly smaller than the Betacam tapes. Panasonic, using the same logic behind VHS-C, sought to reduce the overall footprint of the camera by designing a smaller tape cassette.

6.   8mm

The eight-millimeter cassette is the smallest cassette of all the available analog video formats. Although this format resulted in the smallest and lightest of video cameras, they had no standard VCR playback capability. The 8mm videotape is designed for playback through camcorder itself while connected to a television.

7.   Hi-8 (High 8mm)

The highest quality 8mm videotape available is Hi-8. It remains a marked improvement over VHS and records similar picture and sound quality to that of S-VHS.

The most popular formats today for shooting analog video are S-VHS and Hi-8. These formats are most desirable primarily due to their improved picture and sound quality. Additionally, both of these formats retain a "fair" level of quality from copy to copy as compared to regular VHS and 8mm. However, when analog videotape is compared to digital videotape, its performance, in terms of picture quality and shelf life is less than competitive. Although many S-VHS and Hi-8 camcorders are widely produced and sold, digital camcorders are the wave of the future.

C.   DIGITAL VIDEO (DV)

Analog cameras capture light and sound as continuous waveforms; converting them into electrical impulses which alters the magnetic properties of the videotape and thus records images and sounds. However, a computer is not specifically designed to receive and store a continuous waveform. Instead, the digital video camcorder records images and sounds in binary code. As opposed to scanning the subject you are shooting in a continuous stream, the DV camera takes a snapshot of the subject 30 times per second that is recorded by an array of light-sensitive crystals inside the camera. Each snapshot or frame of video is then divided into 345,600 picture elements (pixels).

The light-sensitive crystals inside the camera records the color and brightness of the light received at each pixel in the frame. With the camera sending 345,600 data points per frame, at 30 frames per second, each second of video produces more than 10 million numbers or at least 10MB of picture information per second. The obvious result of such a high sampling rate is digital video can better capture the most subtle changes in color,

light, and sound than traditional analog equipment, resulting in a higher picture and sound quality.

D.   BENEFITS OF DV

Digital video technology allows one to capture more data than traditional analog video.   The following is a discussion regarding how digital video provides improved picture quality over analog formats.

1.   Lines of Resolution

Video quality is often measured in terms of lines of resolution.   Lines of resolution refer the total number of horizontal stripes of color that appear on a television or monitor. More lines of resolution result in the greater definition and clarity of the video picture. Figure 6 provides a comparison of the various formats' lines of resolution.

Lines of Resolution Comparison

Format	Maximum Lines of Resolution
DV	500
DirecTV	400
S-VHS, Hi-8	400
TV	300
8mm	280
VHS, VHS-C	240
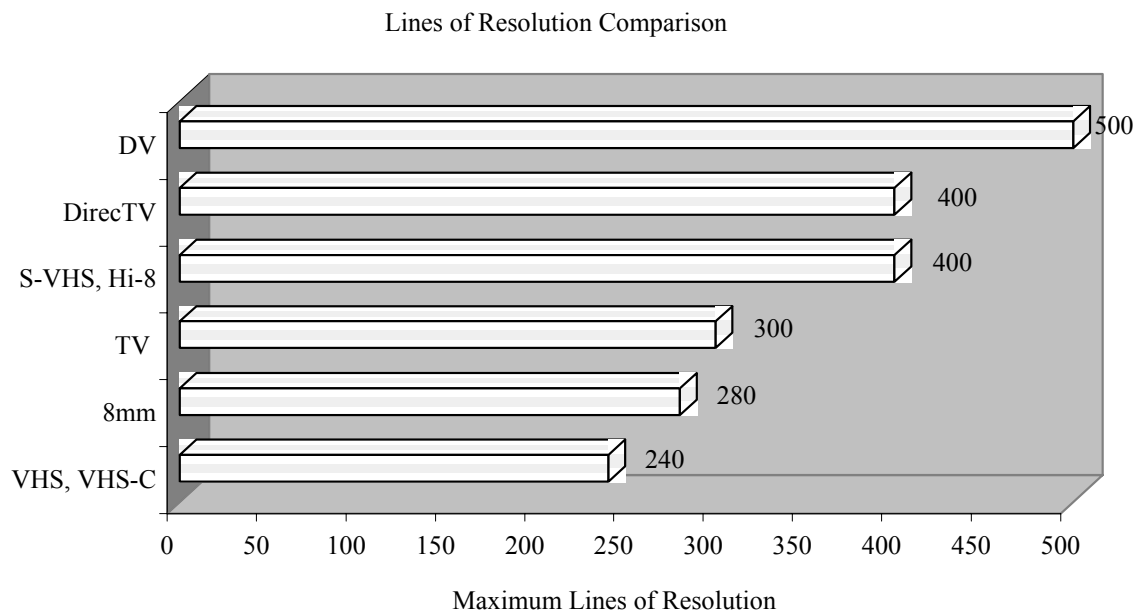
Figure 6.   Video Format, Lines of Resolution

2.   Improved Sound Quality

A DV camcorder records sound at a significantly higher frequency and greater spectrum width than its analog counterpart. A DV camcorder possesses the capability to record CD-quality audio (Steward, 2002).

3. No Generational Loss

The signal on analog videotapes can begin to deteriorate in as short a time as ten years. Transferring fading videotape to a fresh one only worsens the quality of the footage. There currently is no method to preserve footage capture on analog videotape indefinitely. Digital video alone does not solve this problem entirely. The DV format, like its analog counterpart will too deteriorate over time; however, it has a shelf life of around twenty years as opposed to ten. But when it comes to copying, DV has a distinct advance. Because DV recordings store information recorded as binary (1s and 0s) as opposed to oxidized tape, a copy of a DV recording will retain the same picture quality as it is transferred from copy to copy.

4. Editing Ease

Before the advent of DV, editing and applying post production efforts to captured video was cumbersome and expensive. Hundreds of thousands of dollars could be spent on a typical analog video-editing suite. However, with DV and personal computers, the cost of editing and postproduction is significantly reduced through powerful software packages that ease the burden of tedious editing and lengthy time spent in postproduction. Clearly DV outperforms traditional analog videotape in all critical categories.

E. CAMCORDERS: BASIC FEATURES

With many different digital camcorder models available on the market today, it is sometimes difficult to ascertain the critical differences between them. Training and education organizations should look for the following essential camera options when considering a digital camcorder purchase.

1. Charge-Couple Devices

Charge-couple devices (CCDs) are electronic plates in the camera that are covered with individual light sensors. The light sensors convert light energy into a digital signal. Professional camcorders use three CCDs and capture the best color and sharpest pictures. However most consumer camcorders use a single CCD and render adequate picture quality for training and education video content.

2. Zoom

Optical zoom physically moves components in the camera lens assembly to focus on areas as necessary; permitting full resolving capability throughout the camera's zoom range. However digital zoom only magnifies a small portion of the recorded image, thus introducing generational loss into video content. Camera zoom capabilities often differentiate various camcorders from each other, and this feature alone is worthy of consideration during purchase decisions.

3. Microphone

Camcorders with built-in microphones on the front of the camera tend to capture clearer audio than camcorders with microphones on the top. However, built-in microphones in most consumer grade camcorders are insufficient in adequately capturing sound for use in training and education video content. Training and education organizations should purchase additional microphone equipment to capture sound for use in video content.

4. Low-Light Recording

Adequate lighting is essentially for capturing the high-resolution video content with DV camcorders. Many camcorders offer built amplification circuitry to improve picture quality in lower light conditions. Training and education organizations should consider this feature as a requirement. Depending on the availability and practicality of adding lights to educational settings, low-light recording may be the easiest solution.

VI. EDIT

A. SYSTEM REQUIREMENTS

To adequately edit digital video, a relatively fast computer with a large hard drive is required. Additionally, an adequate video editing software application and storage system will be necessary to complete the editing process.

1. System Requirements: Hard Drive

The larger the hard drive the better. The reason for the large hard drive is not based on capacity alone. Digital video files take up a large amount of disk space – 1 hour of digital video occupies about 12 gigabytes (GB) of space on the hard drive. Obviously completed video files need not remain on the hard drive after editing is complete. Completed videos can be archived on other media, thus freeing space for new video files to be edited. However, in some instances a video archiving plan using CD-ROMs may not provide sufficient storage. In such cases where storage capacities are rapidly depleted, DVDs can provide an alternate solution. The lowest capacity, recordable DVD can archive up to nearly 5 GB of data. Both CDs and DVDs are acceptable long-term solutions for archiving digital video projects.

Not only is space a factor but its transfer capabilities as well. When digital video is transferred from a camcorder to a computer for editing, each frame must be stored. If the system's hard drive cannot accept data fast enough, the video software edit program may omit or "drop" frames. Dropped frames will ultimately reduce the quality of the video, resulting in gaps during playback. Larger hard drives on the order of 80 to 120 GB with speeds of 5400 to 7200 revolutions per minute (RPM) are best suited for transfer tasks.

2. System Requirements: Random Access Memory (RAM)

Random Access Memory (RAM) requirements for computers used for digital video editing are significant as well. Professional video editing software suites recommend a minimum of 128MB, and further recommend at least twice that for optimal performance. Computers systems with higher amounts of RAM allow programs to operate more smoothly, allowing for "multiple undos" with video editing applications.

"Multiple undos" are a feature found in most video editing software that allow editors to step backward through recent changes allowing them to "undo" recent edits. The number of "undos" permitted by the editing software is largely based on the amount of RAM a system has available. The more RAM, the faster the editor will be able to render edits and undos.

3. System Requirements: Processor and Processor Speeds

Video rendering is not a function of RAM alone. A computer's processor speed will not only impact rendering and editing but compressing as well. Compressing the video after editing can take hours, depending on its length. The processor speed of the computer system can quicken the process. Like the hard drive system requirements, more is better. Most professional video editing software suites require at least an Intel Pentium III/500 MHz processor for Windows systems or G3/400 MHz for Macintosh systems. However, for optimal performance, most video editing software suites recommend an Intel Pentium 4 or multiprocessor system for Windows systems or G4/400 MHz or multiprocessor system for Macintosh systems.

4. System Requirements: Video Card

A video card is a device that contains its own processor and memory. The primary function of the video card is to boost the performance of graphical and multimedia applications. The processor on the video card is specialized for computing graphical transformations and achieves better results than the main processor of the computer. As opposed to compressed multimedia viewed on the Web or embedded in other applications, raw digital video imported from a video camcorder normally result in large file sizes. Video cards used in video editing must be able to fully display 30 frames per second (fps) of uncompressed, raw digital video. Like the hard drive, system processor, and RAM , more RAM onboard the video card is better; and 32MB is considered the minimum requirement.

5. System Requirements: Firewire Port

In most cases DV content is brought into the computer via an IEEE 1394 connector also know as a Firewire cable. Most DV camcorders and new multimedia

computers come equipped with Firewire connectors. However, for older computers there are alternate solutions made possible by analog to DV bridges.

6. System Requirements: Analog to DV Bridges

Several companies manufacture devices that permit you to transfer analog video into your computer for editing. These devices are convenient in situations where you may have archived material on VHS tape or when an analog tape camera is the only means available to capture video. However, these devices have disadvantages in terms of speed and file size limitations when attempting to transfer.

When importing analog videotape for conversion to digital, the largest frame size possible is 352 x 288 pixels. This small frame sizes are a result of the low data transfer rates associated with Universal Serial Bus (USB) 1.0 and serial ports used for importing. At speed of 12 Megabits per second (Mbps), USB 1.0 ports are not up to the task of moving large frame video. This limitation is acceptable when the final video files are targeted for low bandwidth users. Another disadvantage when converting analog video is generational loss. When you transfer analog tape into the computer, there is a significant drop in picture quality. Combine the subsequent effects of compression and copying, and significant accumulated picture and sound quality generational loss. Therefore, it is best to begin with digital video at the beginning of the process.

B. VIDEO EDITOR BASICS

The basic video editing functions are trimming and margining clips, adding audio, still images, and text. Additionally, most editors permit using transition effects that help sequence the various scenes in a training and education video.

1. Video Editor Layout

The general layout of video editors (Figure 7) can be found on the main screen of the program. Typically most video editors include a preview window for viewing individual video clips or project playback. Most low-to-mid range priced editors use the same window for browsing and video playback. Most editors use a control panel with VCR-style controls for playing, rendering, fast forwarding, and rewinding video playbacks.

Recording normally is a more elaborate process and is usually initiated through various menus. Storage for video clips is typically provided on a "shelf" or "library" during editing and assembling of video content. These resources are kept no more than one mouse click away on the main screen itself, thus providing quick access to video clips for the video project. During editing, video clips and other resources are dragged into a work area where they are sequenced, trimmed, and combined as required. Typically a work-flow menu system is employed to help step editors through the tasks logically. The construction of a video project is a combination of adding and editing video clips along with other media. The editor allows the trimming of individual video clips and facilitates the adding of transitions, music, sound effects, and voice-overs as required. Video editing programs provide quick access to the necessary editing tools, without trying to clutter the screen or overwhelm users by displaying every tool all at once.

Figure 7.   Videotape Editor Layout

2. Basic Video Editing Tasks

Regardless of the video editing software to be used, creating a video content involves a common set of tasks that comprise basic video editing. In this section, the key tasks involved in video editing are discussed. Before assembling video content, organizing resources in separate folders is necessary. There may be video clips, image files, and sound files that will ultimately be included. These resources need to be organized into a file and folder structure while remaining close at hand. Most video editing software packages employ some type of file and folder hierarchy containing the resource files necessary to put together projects. Other programs have users create a new folder for video content, and then the program moves necessary resources as required; either way, the idea is to organize and get resources together for editing.

a. Adding media to the project

For adding and editing media, most video editors provide both a storyboard and timeline view (Figure 8). Each of these views provides access to the various tools required for editing and adds a unique perspective of the video content in work. In the storyboard view, a small thumbnail picture represents each video clip. By dragging video clips and image files to the storyboard, the video begins to take shape. The storyboard allows the editor to see the sequence of media at a glance. Along with a storyboard view, most video editors provide a timeline view.
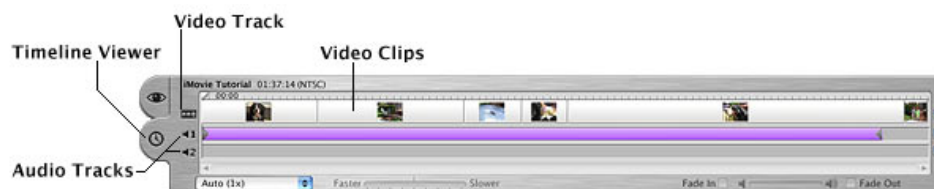
Figure 8.   Video Editing Storyboard View (Apple Computer, 2002)

A timeline view is necessary for isolating a small segment of video requiring editing. In the timeline view, video length is displayed, making it easy to trim footage from a video clip. Some video editing systems permit cutting a segment of video anywhere within the clip and pasting it somewhere else along the timeline. Other editing

software permit dragging the ending of a video clip toward a specified time marker, allowing the clip to be repeated until a specified time is reached.

b.   *Trimming Clips*

The most basic of functions provided by a video editor is trimming individual video clips. All video editing software suites allow the trimming of video at the beginning, middle, and at the end of the video clip. The video editor allows the dropping in of segments anywhere within the project. Most editors allow you select, trim, and move a various clip within a given project allowing the editor to properly sequence video clips for the project.

c.   *Audio Tracks*

Most video editors only allow a single video track to play at a time, but they often support playback of concurrent audio tracks. Multiple audio track playbacks are useful if it is desirable to add music accompaniment with voice over or sound effects. The timeline view is essential for managing multiple audio tracks (Figure 9). Individual control over separate tracks is not always required but useful so as to provide additional narration to training and education video content. To add voice-over narration at specific points in a video project, the time markers on the timeline are essential to determining when to fade audio clips into the video.
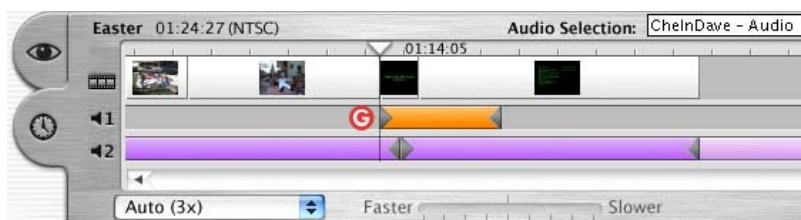
Figure 9.   Timeline View, Multiple Audio Tracks (Baird, 2000)

d.   *Transitions and effects*

Most video editing software suites come with built-in transitions and effects. Transitions are used to blend one video clip into the next. Transitions are simple video effects such as fades, wipes, and dissolves (Figure 10) that can be placed in between different scenes to provide smooth blending between different scenes or clips.

36

Transitions can be overused, but if used sparingly, they can provide a professional feel to a video project.
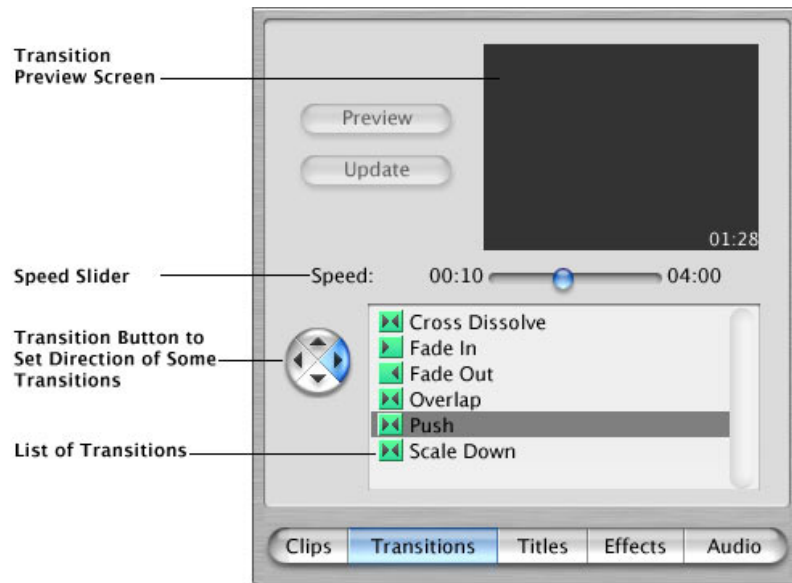
Figure 10.　　Transition Menu (Apple Computer, 2002)

C.　CONSUMER VIDEO EDITING SOFTWARE

Most computers manufactured today already come with video-editing software installed. These video editing software suites perform the most basic video editing functions and are optimally designed for the home use. However, they can provide the necessary editing capability for training and educational video that requires limited editing, such as a lecture or presentation.

1.　Windows Movie Maker

Microsoft Windows XP bundles its Windows Movie Maker 1.1 with all new operating systems. Windows Movie Maker offers just enough functionality to frustrate the user (Graven, 2002). The program includes both a storyboard and timeline views and supports an additional audio track for voice over. However, the program's interface is relatively sparse and offers limited functionality (Figure 11). Transitions are limited to a dissolve effect that is created by simply overlapping two video clips. Most users desiring to build a video project for training and education will require a more powerful product.
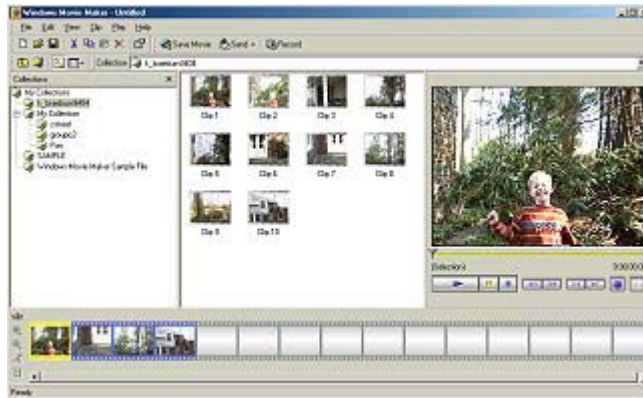
Figure 11.　　Windows Movie Maker (Dixon, 2002)

2.　　Sony MovieShaker

The PCs from Sony include Sony's MovieShaker Software (Figure 12). MovieShaker is comparable to Windows Movie Maker, but it is still somewhat limited in its features. Like Window Movie Maker, it includes both timeline and storyboard views. Additionally, MovieShaker provides a fair amount of effect and an adequate tool to add text titles. MovieShaker's software provides six standard and two random transitions. One of the problems with MovieShaker is the program does not offer precise control over its controls, which is extremely important during video editing. Another problem, its text edit tools do not provide the level of quality required by most organizations. On a positive note, MovieShaker supports video output to MPEG-2 and Real video file formats. Unfortunately, MovieShaker remains best suited for home use and simple editing needs rather than by professionals developing video content for training and education programs.

Figure 12.   Sony MovieShaker (Sony, 2002)

3.   Apple iMovie

For the Macintosh, Apple Computer bundles iMovie (Figure 13) with its operating system software. iMovie was selected as a CNET Editor's Choice (Steinberg, 2000). iMovie's interface design and overall functionality make it the clear winner in the low-end video editor category. The sleek interface consists of a timeline and storyboard palette, main video window, and an effects palette for managing various clips, transitions, text, and audio. Capturing video is easy and precise via scene detection, and a capture button that begins upon playback. Effects and transition options are easily selected and placed onto the timeline or storyboard where desired. Additional titling and other functions work in a similar fashion, making iMovie the easiest to use while providing professional results.

Figure 13.   Apple iMovie (Apple Computer, 2002)

"Pro-sumer" products refers to a genre of products which are can be used by professionals and consumers alike.   Pro-sumer programs offer advanced features not found in editing suites targeted at novice or amateur users and are priced below $1000. The following discusses the relative merits of the more popular pro-sumer video editing software suites.

5.   Pinnacle Systems Studio DV

Pinnacle's Studio DV (Figure 14) took top honors in PC Magazine's video editing software analysis (Ozer, 2002). Studio DV's highlights include a flexible time interface coupled with a sophisticated set of output tools.   Like iMovie, Studio DV's editing timeline view give you precise control over video and audio tracks. However, the smart capture tool of the program is worthy of special notice. Studio DV's "Smart Capture" tool records imported video at a lower resolution to save storage space. For example, one hour of digital video typically requires 12 GB of disk space; but with Smart Capture that same hour would be stored in only 150 MB hard drive space.   By sacrificing video quality during editing, Smart Capture saves precious disk space.   When it comes time to export the video output, Studio DV automatically re-digitizes the final video at full resolution to either QuickTime, DV, or AVI formats.
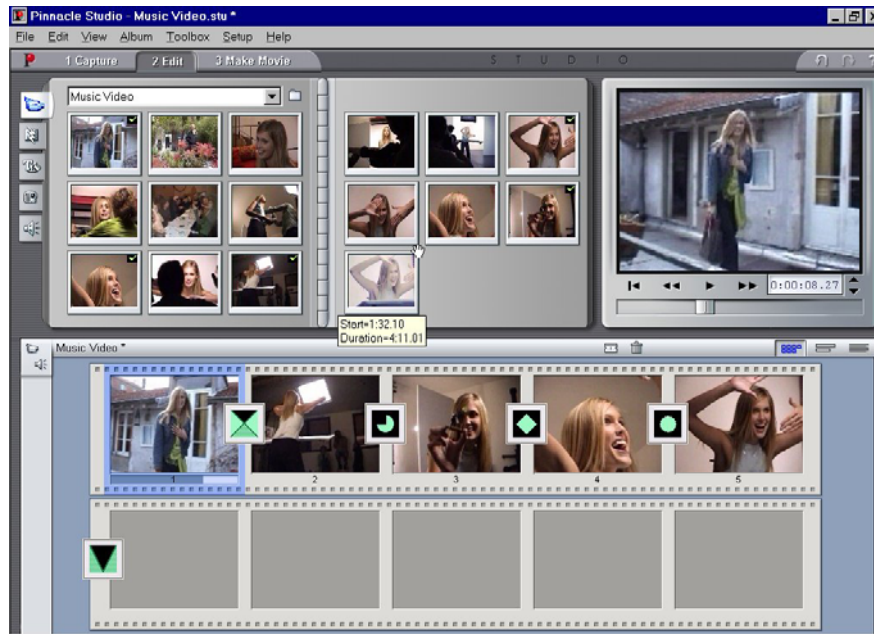
Figure 14.   Pinnacle Studio DV (Pinnacle Systems, 2002)

6.   Adobe Premier

Adobe Premier 6 (Figure 15) provides a single environment that focuses on optimizing the editing process through customizable workspace layouts. Premier appeals to professional users by accommodating varying editing needs and single-press keyboard shortcuts. The major advantage afforded by Premier is its integration within Abobe's other graphic and media software: Illustrator and Photoshop. Graphics from Illustrator and Photoshop are easily imported into Premier, thus assisting in the production of high-quality, professional looking titles and other text integrated with edited video. Premier ships with the largest variety of effects and transitions and support video exporting to multiple Web video file formats. Premier not only exports QuickTime and AVI files but Real Video and Window Media as well. Adobe's voluminous support resources coupled with its top-notch software make Premier the superior sub-$1000 video editor (Holsinger, 2001).

Figure 15.   Adobe Premier (Adobe Systems, 2002)

7.   Apple's Final Cut Pro

Final Cut Pro 3 (Figure 16) is Apple's professional digital video editing software application.   Final Cut Pro is oriented to digital video and graphic professionals.   It features more complex editing techniques such as composting (superimposing) and other special effects. Final Cut Pro gives editors controls to ensure video colors and brightness settings within industry guidelines suitable for television broadcast.   Advanced color filters and correction tools provide unmatched control over output video color and brightness (Heid, 2002).   Final Cut Pro is for serious video productions where professional editing and effect creation is required; it is the most impressive software based editing program on the market but is too complicated for the average amateur user (Holsinger, 2001).

Figure 16.   Final Cut Pro (Apple Computer, 2002)

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VII. COMPRESS

A. WHY DV FILES REQUIRE COMPRESSION

As previously discussed, DV files are quite large; each second of video produces at least 10MB of picture information per second. That is just the video portion and the accompanying sound track to this file only exacerbates the already large file sizes accompanied with DV files. As of the summer of 2002, the majority of Internet connections cannot adequately handle large files of video content. It is important to recognize the limitations of the various delivery options for DV files. Performance trade-offs exist for each option available in which to deliver DV content.

B. COMPRESSION BASICS

Data compression is the process of converting the raw data of a given file into an output stream of reduced size. In general, the process of compression requires the elimination of redundant information (data) by a "loss-less" or "lossy" process (Tomasi, 2001). A loss-less process is used when data integrity and accuracy are paramount. For example, a loss-less process would be used for the transmission of financial data. In contrast, a lossy process permits a certain level of accuracy degradation in exchange for increased compression levels, thus resulting in smaller output file sizes. Lossy compression is used quite effectively when applied to audio/video media. Due to the physical limitations of the human ear and eye, audio and video output files could accept an imperfect reproduction without a noticeable degradation in sound or picture quality from the listener or viewer's perspective. The ability to compress audio and video information, even with some loss of the original quality of data, is an essential element to bringing sound and pictures to viewers.

C. COMPRESSION TECHNIQUES

Data compression occurs when a stream of bits are transformed into their associated codes. A fundamental law of compression is to assign short codes to common bit patterns found within a string of bits, whereas longer codes are assigned to the rarely occurring bit patterns (Tomasi, 2001). To ensure the compression remains effective, the resulting codes are in fact shorter than the original string – smaller in size than the

original bit patterns. The mathematical model in which codes are assigned to various bit patterns is performed through a collection of rules used to process input bits and to determine which codes to output. A given compression algorithm then applies the method to accurately define the probabilities for each bit pattern to produce an appropriate code base on those derived probabilities. The resulting sum of modeling and coding produces a desired level of data compression. The entire process is referred to as coding. For lossy video compression, various mathematical models, such as Discrete Cosine Transforms (DCT), Discrete Wavelet Transforms (DWT), Fractal Transforms, and Hybrid Wavelet-Fractal Transforms are applied to achieve desired compression.

D.   COMPRESSION – DECOMPRESSION (CODEC)

Codec is short for Compression-Decompression and implies a type of compression model. In its most basic of forms, a video codec is a software module that translates the pixel-by-pixel description of a given digital video clip into a compressed format on the input side; subsequently, the same software module decompresses or untransforms the clip during playback. Several professional associations, engineering consortiums, and various standards bodies, attempt to establish and to maintain appropriate standards regarding codecs. Each of the various codec implies a certain level of picture quality, picture size, frame rate, and is typically suited for certain types of delivery. The following summary provides an overview of the major codecs in use today.

1.   H.261/263 Codec

The H.261 codec was primarily designed for use with teleconferencing applications. Its primary function is to carry video over Integrated Services Digital Network (ISDN) connections having data delivery capacities from 128 kbps to 1.544 Mbps. Compression ratios for the H.261 and H.263 codecs are rather extreme, which ultimately reduces picture quality (Pouge, 2001). The H.263 is an improvement to H.261, specifically designed for low bit rate applications. The H.263 is slowly replacing H.261 in many software applications. Both H.261 and H.263 share a similar coding algorithm. Although H.261 and H.263 use an encoding algorithm similar to the Motion Picture Experts Group standard (discussed later in this chapter), both require substantially less CPU power for real-time encoding (Alesso, 2000). The H.261 and H.263 compression algorithms attempt to optimize bandwidth usage by trading picture quality

for movement. The result is high quality for relatively static pictures but lower quality for a picture having significant movement. H.261 and H.263 compression methods are performed via constant-bit rate encoding, rather than constant-quality bit rate encoding.

2.   Cinepak Codec

The Cinepak codec accommodates slower transfer rates making it ideal for compression of video files destined for CD-ROMs or for slower hard drive equipped computers (Steward, 2002). This particular compression method is very effective in returning very small video files. However, this level of compression comes at a cost to quality as well. Video files compressed via the Cinepak codec often suffer from degraded picture quality; and the time to compress is often significant, thus requiring a high performing system to encode those files (Pouge, 2001).

3.   Intel Indeo Codec

The Intel Indeo format is very similar to that of the Cinepak codec in that they both create highly compressed digital video files, which are ideally played back via a CD-ROM. The codec employs a very efficient coding scheme (Steward 2002) that returns video files slightly higher in quality and compress about 30 percent faster than the Cinepack codec (Pouge, 2001). Despite its name, the Indeo codec does not play very well on Windows-based computer systems.

4.   Sorenson Codec

The Sorenson codec is considered the best all around codec for video compression. This codec provides excellent compression without a significant degradation to picture quality. However, Sorenson coded video files require a fairly fast computer for playback, especially with larger frame sizes (Pouge 2001). Sorenson is very popular for compression video files used for CD-ROM playback or over a network (Steward, 2002). The Sorenson codec is not platform specific − Sorenson compressed files can be viewed on Macintosh, Windows, or Linux operating systems.

5.   MPEG Codecs

The Motion Picture Experts Group (MPEG), a working group for the International Organization for Standardization (ISO), have established requirements for a vast collection of compression formats for optimizing video playback. The MPEG codec

generally outputs higher quality video files than H.261/263, Cinepak, Sorenson, and Indeo codecs. The MPEG codec is able to achieve such higher compression rates than the competing codecs by storing the changes from one frame to another, vice the data in each and every frame (Webopedia.com, 2002).

a. MPEG-1 and MPEG-2

The MPEG-1 and MPEG-2 standard are compression methods that provide interoperable codecs for digital video files. The MPEG-1 codec targets a delivery range from 1Mbps to 1.5 Mbps, thus providing VHS picture quality for a frame size slightly larger than 320 x 240 at a frame rate of 30 frames per second (Chiariglione, 2001). Unfortunately, MPEG-1 requires extensive hardware for real-time encoding. Although decoding can be performed via software, a fairly high-end computer system is required for playback. The MPEG-1 standard does not offer resolution scalability, thus it is susceptible to quality degradation making it less suitable for video teleconferencing than H.261 and H.263 (Alesso, 2000).

The MPEG-2 codec is an extension of MPEG-1 with significant improvements. The MPEG-2 codec includes added support for improved picture resolutions and for increased audio capabilities. The MPEG-2 codec targets a delivery range from 4 Mbps to 15 Mbps, thus providing what is known as broadcast quality, full-screen video (Chariaiglione, 2001). The MPEG-2 codec offers high picture resolutions: 720x480 and 1280x720, both at 60 frames per second (Webopedia.com, 2002). The MPEG-2 encoding standard is widely used in Digital Versatile Disks (DVD) and for high definition television receivers. Unlike it's predecessor MPEG-1, MPEG-2 attempts to cater for scalability and requires even more expensive and sophisticated equipment to encode digital files (Alesso, 2000). However, only moderate computing requirements are necessary for decompressing and viewing MPEG-2 digital video files. Both MPEG-1 and MPEG-2 are ideally suited to the purposes they were established: playback via CD or DVD-ROM. The high quality pictures associated with this type of encoding scheme require significant amounts of bandwidth and were not designed to play across a network.

b. MPEG-4

The MPEG-4 codec is yet another iteration and improvement of the MPEG-1 and MPEG-2 codecs. Originally designed as a compression scheme for suitable use with video conferencing applications, MPEG-4 can delivery video files over a narrow bandwidth with the capability of mixing various media such as video and text, graphics, and various animation layers (Alesso, 2000). Unlike MPEG-1 and MPEG-2, MPEG-4 targets a data rate less than 64 kbps, making digital video files suitable for transmission across a 56 kbps network.

c. MPEG-7 and MPEG-21

The MPEG-7 and MPEG-21 codecs are standards yet to be determined. Currently, MPEG-7 will serve as a complement to MPEG-4, not as its replacement. The MPEG-4 codec defines how digital content is represented, whereas the MPEG-7 codec will attempt to specify how content is described. The MPEG-7 codec will facilitate the exchange of information regarding video content in a more interoperable way. The MPEG-7 codec will make it easier to find video content and improve the ability of content repositories to manage multimedia content (Koenen, 2001). The MPEG-21 codec is an effort to establish an entire multimedia framework for true end-to-end interoperability among the various digital audio and video devices. It remains to be seen whether the representatives from the major digital content stakeholders – music labels, film and television companies, and technology providers, will be able to agree upon a common architecture for the delivery and consumption of digital multimedia content.

E. COMPRESSION OUTPUT OPTIONS

Regardless of the method used to compress a DV file, numerous output options are available to optimize the quality and subsequent size of the file. These output options allow content providers to tailor the compression scheme to achieve the best quality file for the intended distribution medium such as the Internet, local area network, CD, or DVD.

1. Frame Size

Many of the codecs are optimized to deliver a certain frame or picture size. Frame size refers to the given width and length dimensions of a picture or movie. Before any compression codec is applied, most DV cameras capture images at 720 by 480 pixels.

A frame size of this magnitude produces 10MB (approximately 80 million bits) of data per second and will exceed the current average data delivery rate available to users. Therefore frame size reductions will help the codec shrink the amount of data associated with a given picture. Figure 17 is a screen capture of a video file frame size of 480 by 360 pixels.

Figure 17.   480 x 360 Frame Size

The 480 by 360 pixel frame size provides data delivery rates, which after compression techniques are applied are suitable for use in CD-ROM, DVD, and LAN based applications. However, it is possible to make further reductions and maintain an appropriate level of viewing quality. 320 by 240 pixel and 240 by 180 frame sizes are

commonly used over broadband and ISDN network connections. Figures 18 and 19 depict the frame sizes for 320 by 240 and 240 by 180 frame sizes.

Figure 18.   320 x 240 Frame Size

Figure 19.   240 x 180 Frame Size

The smallest standard frame sizes used in video based applications are 160 by 120 pixels. The small size makes them ideal for streaming over the Internet via dial-up modem after compression techniques are applied. Figure 20 displays a 160 by 120 pixel frame size.

Figure 20.　　160 x 120 Frame Size

Frame size reductions are the first steps that are taken to reduce the overall size of a given video files. However, frame size reductions are insufficient by themselves alone – to achieve the smallest files possible, other compression output options are applied to achieve the desired ratio of compression.

2.　　Frame Rate

The overall quality of the compressed DV files is affected by its frame rate or number of frames displayed per second. Prior to applying a compression codec, a raw DV file is captured at 30 frames per second (fps). High frame rates return high data rates. Depending on the intended delivery method of the DV file, high frame rates may be acceptable. However, if the intended delivery method requires a lower data rates, a lower frame rate can be used. The trade-off when using low frame rates is the output quality of the file. Using a low frame rate can result in choppy or grainy playback for viewers.

3.　　Keyframe Rate

Keyframes are used to designate certain parts of the DV file as areas contain considerable subject motion or camera movement. In turn, the codec reduces the amount of compression applied those frames designated as "keyframes." Therefore, it is possible to control the level of compression applied to areas or shot sequences that would

otherwise suffer quality-wise if full compression were applied. However, the more keyframes used results in higher data rates that may not be supported by the intended delivery method.

4. Data Rate

With a data rate option, it is possible to target a specific output data-rate. The highest targeted data rate selected is primarily dependent on the intended mode of delivery for the files. For CD-ROMs, the maximum would be a data rate that matches the data transfer rate of the particular device. However, for faster devices, such as a 24 x CD-ROM drive, providing a file with a matching data rate is possible but not practical. For example, it is possible to provide data rate near 2,400 kbps if the target device is a 24 x CD-ROM; but at this rate, only about 5 minutes of content would fit on the CD itself (Stern and Lettieri, 2001). Data rates larger than 1 Mbps, do not add much in terms of video quality and often result in too large file sizes for storage on a CD.

5. Audio Sample Rate/Bit Rate

The audio sample rate/bit rate option allows the codec to adjust the sound sampling rate. By reducing the sampling rate, the compression ratio of the codec is increased, resulting in a smaller file. Like all of the other options, the trade-off is file size for file quality. Reducing the audio sampling rate too much results in poor sound. What constitutes poor sound depends on the content of the file. Training and education topics in which music or sound plays a critical role should be sampled at or above 44.4 kHz, unless the files are destined for distribution over the Internet. For Web viewing, audio should be sampled at less than 22 kHz mono-channel to save space (Steward, 2002).

F. COMPRESSSION CHOICES AND OUTPUT RESULTS

There are two basic methods for the delivery of video content: via a network or locally. If DV files are delivered via a CD or DVD, the speed of the user's optical drive hardware is one of the factors in choosing a suitable compression method. If the delivery of the various DV files will occur over a network, it is important to recognize the capacity or supported data transfer rate for the medium over which the files will be transferred. Various types of network connections deliver data at different rates and are a

significant factor in choosing the optimal compression method and output choices for the DV files.

Currently the most common method of connecting for users is through a dial-up modem. Other connection options include DSL, cable modem, and Ethernet local area networks (LANs). A dial-up modem is a relatively simple device that connects to the Internet by sending signals through the phone line. Due to current technological and legal restrictions, the maximum dial-up speed permitted is 52 kilobits per seconds (kbps); however, that maximum speed is rarely achieved, even with a 56 kbps rated modem.

A digital subscriber line (DSL) is an "always on" type connection provided through a standard phone line. It uses different frequencies within the same line to surpass the 52 kbps limit on a typical phone line. The speed of a DSL can vary for different reasons but typically are rated around 128 kbps to 1.5 million bits per second (Mbps) for download and 64 kbps to 1.5 Mbps for upload. Cable modems are similar to DSL services, but connection to the Internet is provided via the same coaxial cable that provides cable television. Like DSL service, data delivery rates vary by provider but are typically rated from 500 kbps to 2 Mbps for both upload and download.

Although cable modems have a theoretical maximum data transfer rate of 27 Mbps, individual users are unlikely to achieve such performance; because the maximum data transfer rate is shared among the users on a given "neighborhood" line. Ethernet LANs and Integrated Services Digital Networks (ISDN) are used by organizations to connect its users to one another and to the Internet. Speeds associated with Ethernet LANs and ISDNs vary based on type and configuration but usually range from 128kbps to 1.5 Mbps.

Today's CD-ROMs have an approximate storage capacity of 650 to 700 MBs. DVDs come in two varieties: single-sided and double-sided. Depending on the type of DVD each side can have one or two layers of data. The DVD-5 format is single-sided and single-layered with a storage capacity of 4.7 Gigabytes (GB). However high capacities are available on DVD-18. The DVD-18 format is double-sided, double-layered, with an overall storage capacity of 15.9 GBs of data. Table 1 provides a comparison of various compression output settings. A sample digital video file was

compressed using the Sorenson codec. Various output settings such as frame size, frame rate, and sound encoding were adjusted for optimal performance over the following deliver mediums: modem, ISDN, broadband (high and low), LAN, and CD. File sizes for resulting video files over each medium are calculated for clips at three and fifty minutes. Total hour storage capacities for each resulting video file, for a given delivery medium is provided for both CDs and DVDs.

Delivery Medium	Frame Size	Data Rate (Kbps)	Frame Rate	Audio Sample Rate	File Size: 3.3 min clip	File Size: 50 min clip	Capacity: CD	Capacity: DVD-18
Modem	160x120	24	6	8 bit Mono	1 MB	15 MB	46 Hours	1060 Hours
ISDN	240x180	80	12	16 bit Mono	2 MB	36 MB	19 Hours	441 Hours
Broadband (Low)	240x180	168	15	32 bit Mono	5 MB	80 MB	9 Hours	200 Hours
Broadband (High)	320x240	440	20	64 bit Stereo	15 MB	219 MB	3 Hours	74 Hours
LAN	480x360	768	20	128 bit Stereo	25 MB	372 MB	2 Hours	43 Hours
CD Quality	480x360	1000	30	128 bit Stereo	33 MB	487 MB	1 Hour	33 Hours

Table 1.   Compression Output Comparison Chart

Because most data delivery speeds are limited to approximately to 2 Mbps at best, whether via a network, CD-ROM, or DVD, some type of size reduction must occur to shrink the size of DV files for viewing. Compression-output options determine how much information to include during compression. These functions allow discarding unnecessary data so DV files will be optimized for their intended delivery medium.

VIII. DELIVER

A.   DELIVERY METHODS

There are a variety of methods available to distance training and education organizations to distribute video content. In general, video files can be offered via LAN, the Internet, or from a local disc. Depending on our intended audience's available bandwidth and preferences for use, there are multiple ways to ensure desired content remains available. Serving video across a network presents unique challenges and benefits, which is discussed in this chapter.

B.   STREAMING VIDEO

As digital video has become more popular and viable over corporate networks and the Internet, the term "streaming" is used with increasing frequency. Although the term can connote several definitions, most understand it to mean that when they click on the appropriate link, the digital video file plays immediately rather than having to wait until the entire file is downloaded to their local hard drive. The major digital video file formats support two different types of streaming protocols: Hyper Text Transfer Protocol (HTTP) and Real Time Streaming Protocol (RTSP).

1.   Hyper Text Transport Protocol Streaming

The HTTP streaming method is a media delivery architecture where video files are placed on a "regular" Web server just like other Web files, such as graphics and Hyper Text Mark Language (HTML) files. When users click on a particular video link, the video file is downloaded entirely to the viewer's local hard drive. The format of the video file is recognized and understood by the viewer's Web browser via a plug-in. A plug-in is a software module that provides additional functionality to the browser and facilitates playing various media formats.

The HTTP streaming method is considered "streaming" because the video file will begin playing before the entire file is downloaded completely. The plug-in of a Web browser determines when enough of a given file has been downloaded to enable continuous play until the end of the file (Stern and Lettieri, 2001). The performance of

HTTP streaming depends on several factors such as user connection speed, network congestion, and Web server capabilities.

2. Real Time Streaming Protocol Streaming

The RTSP streaming method is a media delivery architecture that requires use of a dedicated "media" server to deliver video to viewer on an as-required basis. In contrast to HTTP streaming, the video files are not downloaded and stored on the viewer's hard drive. The RTSP streaming supports video broadcasting where all viewers have the capability of viewing the same video data at the same time.

There are two types of RTSP streaming: stored (on demand) streaming and broadcast streaming. Most viewers are familiar with stored video files, which are delivered on-demand and can be found on numerous news media Web sites such as CNN.com and ESPN.com. However, broadcast streaming is similar to an actual broadcast, except instead of video being delivered by radio waves, they are delivered via computer networks. Broadcast streaming requires an additional piece of hardware equipped with special software called a broadcaster. The broadcaster assists in capturing, compressing, and formatting video media for eventual broadcast. High volume broadcasting usually requires multiple broadcasting devices to ensure reliability and quality of service. Typically, one device prepares the video for broadcasting while the other part of the system performs as the streaming server for broadcast.

C. CONTENT DELIVERY CHOICE IMPLICATIONS

Each delivery technique has some inherent advantages and disadvantages. The selection of a means of delivery by training and education organizations should be primarily based on providing the best viewing experience to the learner as possible for a given instructional design. Familiarity with the various strengths and weaknesses of HTTP streaming, RTSP streaming, and CD content distribution methods are essential.

1. Picture Quality

Between HTTP and RTSP streaming techniques, HTTP streaming usually permits content providers the ability to provide higher data rates. These higher data delivery rates permit higher quality files to be made available to viewers. The disadvantage of having the ability to support higher data delivery rates is the lengthy download times associated

with the files. Additionally, viewers must be willing to wait for these files as well, often times needing a high-speed connection to endure the longer download times.

The HTTP streaming method guarantees the delivery of all of a given video files data, no matter how long it takes. The implication is there will be no dropped frames or missing information data that will lead to picture quality degradation. With RSTP streaming, there is no guarantee for the complete delivery of data. Consequently, viewers may experience dropped frames, excessive pixilation of images, or "jerky" motions if the network cannot deliver all of the data on time. If the network becomes overly congested, viewers may be unable to view or hear all of the data intended for them. However, with RSTP streaming, viewers will experience what they do see at the intended time; similar to a broadcast. Depending on the type of training and education being offered, missing some of the data, some of the time, may become unacceptable from a learning perspective.

For best picture quality, the CD or DVD will provide the largest, and richest quality pictures. Most of the streaming methods are designed to deliver a smaller picture, approximately 240 x 180, at 12 to 15 frames per second. Because there is no network transfer involved with a CD or DVD, picture quality can be as large as 720 x 480, at 30 frames per second. If picture quality of video multimedia is of paramount importance in the instructional design of a given the training and education module, then CDs and DVDs are the delivery means of choice.

2.   File Size and Performance

For individual video files longer than five minutes, RTSP streaming is usually a better choice than HTTP streaming. When downloading larger files, HTTP streaming can present problems for viewer connecting to the network without a high speed connection. Additionally, those viewers lacking adequate hard drive storage space and system processor speeds on their local machines tend to be frustrated with HTTP streaming architectures. Simply, the files take too long to download and users become impatient waiting to the video to begin playing.

With RTSP streaming, there is only a small "priming" file to download before the entire video file begins to play. Under an RTSP streaming architecture, viewers can

easily fast forward ahead through a video file and only have to wait a few seconds until the video playback begins to play at the new start point. Such functionality is not possible with HTTP streaming. With HTTP streaming, viewers cannot randomly access portions of a particular clip without downloading the entire file first.

Both types of streaming are suitable depending on the instructional design of a given course. If the course is supported by videos that are most likely to be watched once, RTSP streaming is suitable. However, if it is anticipated that students will watch the video repeatedly, viewing the file on a CD or DVD will provide a more satisfying experience.

3.   Content Control and Ownership

If retaining control of downloadable video media is important to the organization, then RTSP streaming should be the delivery means of choice. The RTSP streaming method maintains the video file on the server side; video files are played through the viewer's computer, and the video file is not downloaded to the local computer. This type of streaming may be important to organizations where allowing viewers to download and use as they see fit is not desired. With CDs, DVDs, and HTTP streaming, video files are at the disposal of the viewer. Viewers are able to reuse, copy, modify, and distribute the files in any way they desire. There may be legitimate reasons that an organization may not want users to "own" a copy of the certain video files. Issues pertaining to version control, updates, and security can also influence the method in which organizations choose to distribute video content.

D.   HARDWARE AND SOFWARE OPTIONS FOR STREAMING

Most organizations have only two choices when considering the various streaming systems to support training and education video files: hardware-based MPEG encoders or software-based encoders used in conjunction with streaming servers. Most organizations are attracted to the low cost of software-based encoders with streaming servers because those servers are often free. Furthermore, streaming servers do not incur the bandwidth penalty subject to hardware-based encoding systems. However, if picture quality matters, hardware-based encoders can provide superior quality video for viewers.

1. Hardware-based MPEG encoders

While hardware-based MPEG encoders offer the best picture quality, they also come with the highest entry costs and greater costs per seat than do the software based encoding solutions (Woods, 2002). The MPEG encoders have an advantage in that they do offer a single-box alternate that does not require any additional hardware outside a video source and network connectivity. Such stand-alone capability has its drawbacks, because such independence often leads to poor interoperability among various enterprise-level architectures. The following discussion provides a survey of the most popular hardware-based MPEG encoders.

a. *Amnis Systems NAC-3000*

Amnis Systems NAC-3000 Live Streaming Video Server and Encoder (Figure 21) won rave reviews in Network Computing Magazine's Editor's Choice Awards (Woods, 2002). The NAC-3000 is a one-box solution for both MPEG–1 and MPEG–2 encoding and streaming. The only shortcoming of the system is that it lacks a fully graphical user interface, and it can be difficult to install and administer. For best performance, the NAC-3000 streams MPEG–1 files with a smaller frame size of 352 x 240. The NAC-3000 does offer one function not found on other hardware encoders. The NAC-3000 has the ability to record a live stream while broadcasting (Amnis Systems, 2002). Education and training organizations will find such a feature extremely useful in capturing "live" broadcasts for archive purposes. Such functionality and performance comes at a price; depending on configuration the NAC-3000 costs between $7,000 and $14,000.

Figure 21.   NAC-3000 Streaming Video Encoder (Amnis Systems, 2002)

b.   *Vbrick Systems*

VBrick Systems encoders (Figure 22) come in various models and offer a wide range of encoding solutions. VBrick's systems consistently receive high marks from reviewers for ease of administration and set-up (Woods, 2002). The VBrick can provide both MPEG-1 and MPEG-2 streams at a picture quality similar to the Amnis offerings. One criticism of the VBrick systems is the inability to alter the encoding bit rate below preset levels (Woods, 2002). This oversight makes it difficult to properly manage bandwidth resources across the application. Similar to the Amnis encoders, the VBrick system does not come at a low price. System prices ranges from $5,000 to $10,000.

Figure 22.   VBrick Systems 3200 Encoder (VBrick Systems, 2002)

2.   Software-Based encoders

Software-based encoders provide a high degree of interoperability among various enterprise level architectures.   The three most popular software based encoders on the market today come from Apple Computer, Microsoft, and Real Networks. All three of their software-based encoders offer compatibility over multiple operating systems. All perform well; transmitting good quality pictures at high bandwidths. All three require at least one computer to encode video files in preparation for delivery and a second machine to deliver or stream the media itself. Consequently, software-based encoders are more difficult and complex to administer than their hardware-based counterparts.

a. Apple Darwin Streaming Server

Most people hearing the words Apple Computer automatically will incorrectly assume streaming over Macintosh networks only. However, Apple's Darwin Streaming Server is compatible with several different operating systems to include Windows. In blind tests conducted by Network Computing, judges picked images from Apple's Darwin Streaming Server having the "best picture quality" among the three software encoders surveyed during testing (Woods, 2002). Another attractive feature of Apple's software encoder is the price: it is free. Darwin's browser-based interface allows administrators to easily build "playlists," which are essentially customized lists of files to be played in succession. Likewise, the playlist helps facilitate management of server settings and preferences. To set up video files for play, administrators simply copy files to Darwin and place them in the appropriate directories specified to contain video files.

b. RealNetworks' RealSystem iQ Server

Among the streaming servers, RealNetworks' RealSystem iQ Server is by far the most expensive. RealNetworks variable pricing scheme based on numbers of streams provided can become expensive for organization with larger needs. For example, an organization of 500 users would by approximately $4,000 for the serving software alone (Woods, 2002). The RealSystem iQ Server interface is not as intuitive as Apple's Darwin. However, RealNetworks provides excellent documentation to assist administrators getting the server software up and running. Additionally, judges in Network Computing Magazine independent testing concluded the RealSystem iQ Server was ideal for delivering streaming video at low data delivery rates such as 56 kbps Internet connections.

E. AUTHORING TOOL AND DELIVERY SYSTEM RECOMMENDATIONS

Because authoring tools and delivery systems are somewhat sophisticated, it is paramount for training and education organizations to understand exactly how they will use such tools and systems. Before shopping for tools and delivery systems, training and education organizations should focus on three basic factors: technology needs, business needs, and instructional needs (Webb, 2002). Training and education organization should

consider the limits of the organization's systems in order to better assess their needs for the various video authoring and delivery systems:

- Does the organization use Macs or PCs?

- Does the organization mandate a standard hardware and software configurations?

- Do learners have the access to the required plug-ins needed to utilize organizational video content.

- Are there implications of running courses under some type of learning management system.

As training resources become scarce, training and education organizations must be cognizant of existing budgetary realities. Training and education organization should consider the following:

- Does the organization have an adequate budget for developing, authoring, and delivering video course content?

- Does the development group have experienced video developers or novices?

- Does the organization intend on using teams of developers or a single person?

- What are the start-up costs associated with cultivating video professionals within the organization?

Most importantly, training and education organizations must consider the instructional needs of learners. How important is the quality of video content to the overall desired educational outcome of a given training and education module? Once organizations use these criteria to narrow the field of options in regard to authoring tools and delivery systems, the selection process becomes somewhat subjective. Training and education organizations that are responsible for developing large amounts of video content may find efficiencies in having more than one tool. It is recommended that training and education organization experiment with trial versions of the various authoring tools and experiment with delivery methods to determine which one best fit given instructional designs.

IX.   FUTURE TRENDS

A.   HIGH SPEED NETWORKS

To deliver high quality video content via the Internet, high capacity networks are a requirement.   Nielsen Net Ratings, the global standard in Internet audience measurement, recently reported that subscribers in the largest broadband markets are increasingly turning to high-speed networks. From 2001 to 2002 broadband subscribers in major metropolitan areas rose approximately by 48 percent (Nielsen Net Ratings, 2002). Increased consumer adoption of high-speed networks will continue to promote the feasibility of offering training and education content via the Internet. Although more and more users are turning to broadband access, there is concern the Internet may be becoming over-subscribed (Welsch, 2002).

Video applications stretch the performance of the high-speed network infrastructures.   Even though improvements in compression algorithms continue to squeeze video files smaller, there lacks a "fast-lane" in the network architecture that permit high-performance video users to avoid the gridlock of normal Web users. Internet2 (I2), a nonprofit research consortium, was established in 1996 to address the limits of the current Internet infrastructure (Internet2, 2002). Internet2 seeks to provide an exclusive, high-speed network for 190 member organizations. Members pay from $500,000 to $1 million for access to its 10,000 mile fiber-optic backbone (Welsch, 2002). Internet2 is separate from the commercial Internet and is capable of delivering approximately 155 Megabits per second (Mbps), which equates to about 100 times faster than today's average consumer broadband connections.   Information systems architectures such as Internet2 make it easier for educational institutions to provide high-quality video content to online students.

B.   OPTICAL MEDIA STORAGE CAPACITIES

Current generation optical disc media such as CDs and DVDs have limited storage capacities of 700 Megabytes (MB) and 17 Gigabytes (GB) respectively. However, recent breakthroughs in laser technology looks to dramatically improve the storage performance of optical discs.   By the end of 2003, it is expected that computer

systems will be equipped with next-generation CD and DVD players and recorders. The new systems will employ blue-violet lasers that have the capability to burn 13 hours of full DV quality video content on to discs (Kunni, 2002). Although the technology is proven, any confusion among consumers regarding competing standards between the various vendors may delay the widespread adoption of the new technology. However, when high-capacity CDs and DVDs finally arrive, they will permit training and education organizations to pack even more digital video content on discs for wide distribution of video content in support of distance training and education materials.

C.   POCKET VIDEO PLAYERS

Portable video players have been in the consumer markets for a few years. Portable DVD players are quite commonly used as entertainment devices for those travelers who can afford them. Intel Corporation recently announced it has developed the underlying technology for a small-sized pocket video player (Figure 23). Intel's device will be able to store as many as 100 hours of video programming in its internal hard drive (Wingfield, 2002). Using Intel's technology, Emerging Platforms Lab has designed what it calls a personal video player. The player is a handheld digital-movie player that could be built by a licensed consumer electronics manufacturer and sold for under $400. With it, anyone could be able to experience training and education video content during a plane trip or during a commute to work. The prototype player includes a four-inch color display and is built around a 400-MHz Intel XScale processor, a 30-gigabyte Toshiba hard drive that holds 100 hours of video, and a battery designed to last for several hours (Aston, 2002).

Figure 23.   Pocket Video Player (Intel Corporation, 2002)

D.   FINAL THOUGHTS

Thirty-five years ago only a few people knew how to produce video content; but as video editing technology becomes more widely available, training and education organizations can begin developing their own video content.   Most discussions of learning, whether resident or nonresident, often consider the impact of multimedia. Media elements such as graphics, film, audio, and video have been used in training situations for years.   However, many training and education organizations were unable to leverage video technology for various reasons surrounding digital video production. Today, computer technologies now offer opportunities for training and educational institutions to create their own multimedia.   Despite this new capability it must be remembered that the "media" should only be used to support learning; it is only one of the many parts comprising the greater overall instructional design of a given course.

Video content and other multimedia can add value and make information and educational materials easier to grasp, while improving the overall quality of the learning experience.   But simply adding video content to a poor instructional design will not improve distance training and education alone.   Worse yet, when video and multimedia design becomes confused with instructional design; the result is great looking courses that fail to reach desired educational outcomes.   If close attention is paid to instructional design, the matching of appropriate media content and the instructional outcomes can be optimized.   The richness and easy access of video content is important to allow distance learners to immerse themselves in training and education content.   Video breathes life into traditional text-based correspondence courses, adding real authenticity and impact.

Training and education organizations are faced with many variables when considering an enterprise video strategy.   Training and education professionals tasked with developing an enterprise video strategy must consider instructional design requirements prior to evaluating alternative choices pertaining to planning, capturing, editing, and delivering digital video content.

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LIST OF REFERENCES

Adobe Dynamic Media Group, "A Digital Video Primer," [http://www.adobe.com/motion/primer], Adobe Systems Incorporated, 2002.

Adobe Support Knowledge Database, "Applying Data Rate Limits in Premier," Support Knowledge Document 315573, [http://www.adobe.com/support/techdocs/a60a.htm], 05 March, 2002.

Alden, J., *A Trainer's Guide to Web-Based Instruction*, American Society for Training and Development, 1998.

Alesso, H.P., *e-Video: Producing Internet Video as Broadband Technologies Converge*, Addison-Wesley, 2000.

Alexander, S., "Do Not Pass Go," *Online Learning*, March, 2002.

Amnis Systems, "Amnis Systems Products," [http://www.optivision.com/products/nac3.html], 2002.

Anzovin, S., "20 QuickTime Tips," *MacAddict,* no. 61, pp. 30-35, September, 2001.

Anzovin, S., "Edit Your Own Screen Test," *MacAddict,* no. 56, pp. 40-45, April, 2001.

Apple Computer Inc., "QuickTime 6," [http://www.apple.com/quicktime/products/qt], 2002.

Apple Computer Inc., "QuickTime Broadcaster," [http://www.apple.com/quicktime/products/broadcaster], 2002.

Apple Computer Inc., "QuickTime Streaming Server FAQ," [http://www.apple.com/quicktime/products/qtss/qtssfaq.html], 2002.

Atkin, D., Grunin, L., and O'Brien, B., "Ready, Set, Video!," [http://computers.cnet.com/hardware/0-1018-8-9389318-1.html], 22 March, 2002.

Baird, J., " iMovie Lesson Three: Editing Music and Sound," [http://www.macworld.com/2000/10/04/imovie.html], 10 October, 2000.

BroadbandBuyer.com, "Broadband Speed and Description Chart," [http://www.broadbandbuyer.com/chartbusiness.htm], 2000.

Carr, S., "As Distance Education Comes of Age, the Challenge is Keeping the Students," *The Chronicle of Higher Education*, February 11, 2000, p. 23.

Chiariglione, L., "MPEG: Achievements and Current Work,"
[http://mpeg.telecomitalialab.com/mpeg_general.htm], November, 2001.

Cipro Inc., *A Primer on Streaming Video*, DeWerd, J., October, 2001.

Client Help Desk, "Average Home Internet Connection Speeds,"
[http://www.clienthelpdesk.com/statistics_research/home_connection_speeds.html], 15
February, 2001.

Cohen, P., "QuickTime Streaming Server gets Well-Connected Awards,"
[http://maccentral.macworld.com/news/0205/14.qtss.php], 14 May, 2002.

Digital Century, "Biography: Glenn R. Jones,"
[http://www.digitalcentury.com/encyclo/update/bio.html], 2002.

Dixon, D., "Windows Movie Maker," [http://www.manifest-
tech.com/media_pc/movie_maker.htm], 2002.

Dreier, T., "RealNetworks RealOne Player, [http://www.cnet.com/software/0-3227898-
1205-8066855.html], 09 April, 2002.

Greenwald, T., "Decoding the Codecs,"
[http://wired.com/wired/articles/7.08/codecs_pr.html], August, 1999.

Guzley, R. and Bor, A., "Simulated Computer-Mediated/Video Interactive Distance
Learning: A Test of Motivation, Interaction Satisfaction, Delivery, Learning and
Perceived Effectiveness," *Journal of Computer Aided Mediation*, Volume 6, Number 3,
April 2001.

Harlan, R., "Digital Video View: iDVD 2 FAQ," *Mac Design,* May/June, 2002.

Harlan, R., "Digital Video View: Why Am I Getting Squished," *Mac Design,*
January/February, 2002.

Heid J., and Wolsky, T., "Final Cut Expert Guide," *Macworld,* pp. 52-60, September,
2001.

Hodgetts, P., "Out of the Box with Final Cut Pro," *Mac Design*, pp. 28-30, March/April,
2002.

Holsinger, E., "Adobe Premier 6.0," [http://www.cnet.com/software/0-3227896-1205-
4175894.html], 01 May, 2001.

Holsinger, E., "Pinnacle Systems Studio DV," [http://www.cnet.com/software/0-
3227896-1205-1432460.html], 20 March, 2001.

Internet2, "About Internet2," [http://www.internet2.edu/html/about.html], 2002.

Kember, L., "Learning New Ways to Learn," *Information Highways*, March-April, 2002.

Koenen, R., "From MPEG-1 to MPEG-2: Creating an Interoperable Multimedia Infrastructure," *EE Times,* 12 November, 2001.

Kunii, I., "Lasers Are About to Enter Their Blue Period," *BusinessWeek,* pp.73-74, 10 June, 2002.

Lengel, J., *The Web Wizard's Guide to Multimedia*, Pearson Education, Inc., 2002.

Levitt, M., "The CynMor Video Digital Video Primer," [http://members.tripod.com/~levitm/whatis.htm], 1998-1999.

Lu, C., "Make an Old-School iMovie," *MacAddict*, no. 60, pp. 60-63, August 2001.

Luening, E., "High-Speed Net Subscribers Surpass 9 Million," [http://news.com.com/2100-1033-267697.html?legacy=cmet&tag=txt], 01 June, 2001.

McGinn, D., "A Debate Over Distance Learning," *Newsweek*, 21 April, 2001.

MCI Online, "History of MCI," [http://www.mci.usmc.mil/aboutmci.history.asp], 2002.

Nasseh, B., "A Brief History of Distance Education," *Adult Education in the News,* 1997.

Nielsen/Net Ratings, "Netreporter: Biggest Broadband Cities get Bigger," [http://www.Nielsen-netratings.com/newsletter/newdesign/products/nr_data.htm#1], 2002.

NYU Online, "Other Distance Education Ventures Closed," *Academe,* p. 6, March-April 2002.

Ozer, J., "Video Editing Software," [http://www.pcmag.com/print_article/0,3048,a=24664.00.asp], 23 April, 2002.

Palloff, R. and Pratt, K., *Building Learning Communities in Cyberspace*, Jossey-Bass Inc., 1999.

Parsons, M., "Put Down that Knife," [http://www.redherring.com/insider/2002/0722/dremedia0702202.html], 22 July, 2002.

Pike, R.W., *Creative training techniques handbook: Tips, tactics, and how-to's for delivering effective training*, Lakewood Books, 1994.

Pittelkau, J., "DV Camcorders," *Macworld*, pp.36-37, December 2001.

Pittelkau, J., "Lights, Camcorder, Action," *Macworld*, pp. 60-65, June, 2002.

Porter, M., "Strategy and the Internet," Harvard Business Review, Reprint R0103D, March 2001, p. 66.

Pouge, D., *iMovie2: The Missing Manual*, Pouge Press/O'Reilly and Associates, 2001.

Preece, J., *Human-Computer Interaction*, Addison-Wesley, 1997.

Public Broadcasting Corporation, "Distance Learning: An Overview," [http://www.pbs.org/als/dlweek/history/index.html], 2002.

Ravitch, D., "Technology and the Curriculum: What curriculum for the Information Age?," 1987.

RealNetworks.com, "RealNetworks Competitive Advantage," [http://www.realnetworks.com/solutions/leadership/advantage.html], 2002.

Rebbapragada, N., "DV Magic," *MacAddict,* no. 69, pp. 39-44, May, 2002.

Rhodes, D., "A Primer: Streaming Audio, Slides, and Video," [http://www.digitalwebcast.com/Htm/Tutorials/streaming/streaming_primer.htm], Digital Media Online, 2002.

Richter, M., "Compression and Decompression: Confusion in a Bottle," [http://www.mrichter.com/cdr/primer/compress.htm], 11 June, 2002.

Rosenberg, M., *E-Learning: Strategies for Delivering Knowledge in the Digital Age*, McGraw-Hill Trade, 2000.

Rosenberg, M.J., *E-Learning: Strategies for Delivering Knowledge in the Digital Age,* McGraw-Hill, 2001.

Schlosser, C., and Anderson, M., "Distance Education: A review of the literature," Washington, D.C., Association for Education Communication and Technology, 1994.

Schmitz, P., "Multimedia Goes Corporate," *IEEE Multimedia,* July-September, 2002.

Sherry, L., "Issues in Distance Learning," International Journal of Educational Telecommunications, Edition 1, Volume (4), pp. 337-365, 1995.

Sipusic, M.J., Pannoni, R.L., Smith, R.B., Dutra, J., Gibbons, J.F., and Sutherland, W.R., "Virtual Collaborative Learning: A comparison between face-to-face tutored video instruction and distributed tutored instruction," Palo Alto, California, January, 1999.

Sitze, A., "Future Shock," *Online Learning*, v. 6, p. 4, February, 2002.

Steinberg, G., "AppleiMovie 2.0.1," [http://home.cnet.com/software], 25 September, 2000.

Stephenson, J., *Teaching and Learning Online*, Stylus Publishing Inc., 2001.

Stern, J. and Lettieri, R., *QuickTime for Macintosh and Windows*, Peachpit Press, 2001.

Steward, W., *Digital Video Solutions*, Muska and Lipman Publishing, 2002.

Stoll, C., *Silicon Snake Oil*, Doubleday, 1995.

Thompson Education Direct, "Our History," [http://www.educationdirect.com/02-our_history.html], 2002.

Tokuda, A., "Create Pro Transitions in iMovie," *MacAddict,* no.72, pp. 58-60, August, 2002.

Tokuda, A., "Create Spectacular Movie Effects," *MacAddict,* no. 67, pp. 68-73, March 2002.

Tomasi, W., *Electronic Communications Systems*, 4th Edition, Prentice-Hall Inc., 2001.

Truman, B., *Digital Video,* University of Central Florida,14 May, 1996.

Underhill, R., *Khrushchev's Shoe*, Perseus Publishing, 2000.

University of Washington, Department of Education, "Web User Trends," [http://www.depts.Washington.edu/trio/train/howto/site/design/stats.shtml], April, 2002.

Webb, W., "One Tool Doesn't Fit All," *Online Learning*, February, 2002.

Webopedia.com, "Graphics Accelerator", [http://www.webopedia.com/TERM/g/graphics_accelerator.html], 18 January, 2002.

Webopedia.com, "MPEG," [http://www.webopedia.com/TERM/M/MPEG.html], 21 June, 2001.

Welsh, E., "Traffic Jam," *Online Learning*, April, 2002.

Whatis.com, "CD-ROM"*,* [http://whatis.techtarget.com/definition/0,,sid9_gci211759,00.html], June, 2002.

Whong, J., "Edit a Multiple-Angle Scene in iMovie," *MacAddict,* no. 63, pp.70-73, November, 2001.

Wildstrom, S., "Developments to Watch," [http://www.businessweek.com/print/magazine/content/02_21/c3784106.htm?mainwindow], 27 May, 2002.

Wiley, M., "Intel PVP Unveiled," [http://gear.ign.com/articles/365/365833p1.html], 24 July, 2002.

Wingfield, N., "Intel Develops Gadget to Store Hours of Video," *The Wallstreet Journal,* 25 July, 2002.

Woods, D., "Hardware of Software? Wading the Video Stream," *Network Computing,* pp. 42-65, 18 March, 2002.

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